JUL 10 1958

THE INSTITUTION OF ELECTRICAL ENGINEERS

JOURNAL

VOLUME 4 NO. 42 JUNE 1958

VOLUME 4 NUMBER FORTY-TWO JUNE 1958

JOURNAL

OF THE INSTITUTION OF ELECTRICAL ENGINEERS

SAVOY PLACE LONDON W.C.2 *Telephone* TEMPLE BAR 7676 *Telegrams* VOLTAMPERE PHONE LONDON

PUBLISHED MONTHLY PRICE SEVEN SHILLINGS ANNUAL SUBSCRIPTION TWO POUNDS

Contents

287 **Engineering and Economics**

289 **Some Notes on the Development of Electric Traction**
by L. COLLINS, B.E., B.SC., MEMBER

294 **Georg Simon Ohm and His Law**
by P. HAMMOND, M.A., ASSOCIATE MEMBER

296 **The Chesters Estate**

298 **The History of Electrical Engineering—8**
by C. MACKECHNIE JARVIS, MEMBER

305 **Wiring Regulations—Recent Interpretations**

306 **International Convention on Microwave Valves**

310 **Third Eusec Conference on Education and Training**

311 **I.G.Y. Progress Report**

313 **A Review of the *Proceedings*, Parts A and B**
(*Details are given in the adjoining column*)

323 **Obituary**

328 **Monographs and Papers published individually this month**
(*Details are given in the adjoining column*)

329 **Technical Publications**

331 **Some Recent Books**

336 **Elections and Transfers**

338 **Library Accessions**

340 **Forthcoming Events**

340 **Contents of the Current Issues of the *Proceedings***

341 **Announcements to Members**

343 **London Report**

346 **News from the Centres**

348 **News from Abroad**

BACK COVER **Index of Advertisers**

313 A Review of the *Proceedings*, Parts A and B

Solid-Rotor Asynchronous Generators	P. Richardson
Effect of Arc Furnace on Electricity Supply	B. C. Robinson and A. I. Vander
Medium-Voltage H.B.C. Fuses	R. H. Dean
Stability Tests on the 132 kV Grid	F. Busemann and W. Casson
Large-Scale Grid Tests	F. H. Last, E. Mills and N. D. Norris
Homopolar Generator with Mercury Brushes	D. A. Watt
Transformers, Regulators and Reactors	E. T. Norris
Conjugate-Impedance Network Analyser	W. Casson and A. W. Hales
Fractional-Slot Windings	J. H. Walker and N. Kerruish
Effect of Voltage Regulator on Stability of Synchronous Generator	A. S. Aldred and G. Shackshaft
Electronic Power-System Simulator	K. G. Corless and A. S. Aldred

328 Monographs and Papers published individually this month

MONOGRAPHS

N-Component Operators for Linear Circuits	A. J. O. Cruickshank
Interference Discrimination in Synchronized Oscillators	R. Spence and A. R. Boothroyd

PAPERS

New High-Speed Digital Technique	D. Eldridge
Performance of Telephone Networks	J. Swaffield and D. L. Richards
Acoustic Design of Small Studios	C. L. S. Gilford

© 1958: The Institution of Electrical Engineers

Secretary W. K. BRASHER, C.B.E., M.A., M.I.E.E. *Editor* W. G. ASKEW, M.C.

Advertising Office TERMINAL HOUSE, GROSVENOR GARDENS, LONDON, S.W.1. *Telephone* SLOANE 7266. *Telegrams* INDULICITY, SOWEST, LONDON

The Institution is not, as a body, responsible for the opinions expressed in the *Journal*, unless it is stated that an article or a letter officially represents the Council's views.

JOURNAL

OF THE INSTITUTION OF ELECTRICAL ENGINEERS

VOLUME 4 NUMBER 42 JUNE 1958

ENGINEERING AND ECONOMICS

ALMOST ALL ENGINEERING IN THE CIVILIAN world is concerned with the objective of increasing economic welfare. In an increasingly capitalistic and specialized economic system the engineer may be remote from the final consumer, but the statement is nevertheless true, for money and the price mechanism provide a practically universal means by which the engineer can measure the effect of his work on economic welfare. He must always be fully alive to the dynamics of the economic system in which he operates and to the complicated interaction of choices between consumers selecting what they wish to buy and producers choosing what they wish to produce. He must know the effect of altering any of the variables in his design to meet the wishes of the buyer; a standardized design, although cheap, may not suit everyone. For these reasons, that branch of economic research which is concerned with markets and consumers will be of great importance to him.

The progress of engineering in any field tends to follow three main lines of development—demonstrating feasibility, developing reliability, and reducing costs to give better value for money. Usually these phases of development are not clearly separated and perhaps not always recognized. Often a mere demonstration of feasibility is sufficient to produce economic gains.

The attitude of much of the engineering industry to-day is that it is looking primarily for economic development, by continued progress along fairly well-worn lines, or by new methods of achieving approximately the same results as before, or by applying existing techniques to new uses. In each of these, economic analysis has a considerable part to play.

Continued progress along well-worn lines holds certain dangers from the economic point of view. For example, in power stations there has been a continuing economic trend towards higher steam temperatures and pressures to reduce the cost per unit. The danger here might be that, almost by force of habit, the trend of design could come to be regarded as an end in itself rather than as a matter purely of economy. This might lead to a failure to recognize that a change in environment, e.g. of fuel prices, plant costs, the expense of borrowing money, the skill of labour, transport charges, etc., could change the whole basis of power-station economics.

A second important pitfall lies in the use of that vague but overworked concept *efficiency*. We may all think we know what this means, but in fact the use of the term by itself is a barrier to clear thinking and the accurate exchange of ideas. It is always necessary to ask exactly what we mean by efficiency. We may mean that a piece of equipment performs all the tasks it is called on to do accurately, that it never breaks down, that the ratio of output energy to input energy is high, and so on. Except in very limited cases where a single precise objective is defined, efficiency can only be a compromise between various conflicting requirements and cannot therefore be measured except by a subjective evaluation of the relative importance of the different requirements. Thus it is necessary to remember that, unless we are defining efficiency precisely, as in thermal efficiency, we are thinking of a compromise, and it is better to state merely that our piece of equipment reliably performs function A 100% of the time and function B, X% of the time, that its energy balance is Y, its running cost Z and its capital cost C, and so on. This should be a clear statement of all the relevant facts which might be considered important in a comparison between two alternative pieces of equipment. In engineering equipment, or a business organization, the use of the term 'efficiency' in a general way can only lead to misunderstanding and confusion. For example, there has often been argument about whether the gas industry or the electricity industry uses coal more efficiently. It is possible in this case to define efficiency in several ways, all fairly precise, but do any of them have any significance? The answer must surely be that an economic comparison is the method of combining all the relevant facts which comes nearest to being valid.

The second and third forms of economic progress, using new methods to achieve approximately the same results as before, or applying existing techniques to new uses, generally involve making economies in the use of scarce resources. Often a change of this kind results,

paradoxically, in further complication of the organism which is being improved; and here detailed and careful analysis of its working and costs in various possible conditions and with various possible values of the variables and parts making up the organism is required. This sort of study frequently embraces engineering, economics, statistics and what are now called operational research and management accounting. It is important here that the engineer should recognize when the study is one which he himself can carry out quickly and when the problem is largely outside the scope of his work so that he would be well advised to call on other disciplines.

It cannot yet be said that the engineering industry, particularly the heavy section, is making enough use of economics, statistics, market research and operational research. This is surprising in an industry which is so intimately concerned with economics. As engineering design and the economic system become more complex, the scope in the engineering industry for skills other than that of engineering must increase. In the present situation, the industry must open its doors wider to other skills and explain its methods and problems. Reciprocally, a wider background knowledge of these other skills should be encouraged in engineers, not with the object of making them jacks of all trades, but to enable them readily to recognize, indeed to look for, problems which are not primarily or wholly engineering ones. Such problems as the improvement of a design or organization for maximum profits, minimum costs, or whatever other optimum is chosen, and the questions of reliability, spare capacity, maintenance, breakdowns, rejects, stock holding, inspection and so on are all partly concerned with economics and statistics. The engineer likes to be able to concentrate on his proper work and may tend to regard the economic world outside it as static, rather than concern himself with too many imponderables. He needs, however, a sense of the dynamics of the non-engineering world also.

To attain this broadening of outlook in the most useful, as distinct from the most educational, way, the subjects which he might study are economics, the methods of market research, operational research, work study and statistics. Within the subject of economics, an examination of the methods of analysis, marginal costs and the theory of the firm, the function of money, the price mechanism and the market economy would be much more valuable than particular studies of engineering economics, since the object should be to encourage analytical thinking and imagination rather than the rigid following of methods and formulae.

While such subjects could usefully be included in undergraduate engineering courses, a possibly more valuable arrangement would be post-graduate courses of several weeks' duration, including discussions, designed for practising engineers. In this way the exchange of ideas between engineers and economists would broaden the outlook of the former and bring the latter down to earth. Ideally, the lecturers would include both university staff and industrial and commercial economists, statisticians, market researchers, etc. The result could be a much greater understanding of the contribution that well-integrated teamwork can make to economic progress.

Commuters and Computers

OPERATING staff of the London Midland and Eastern Regions of British Railways are applying an electronic computer to the problem of revising and constructing railway time-tables.

London Midland are trying to instruct the computer to provide timings for special trains superimposed on the time-table train service. At a later stage, they plan to carry out a seasonal revision of the existing time-table for a chosen section of line with the object of improving the passenger train services. Eastern intend to use the computer to produce a time-table making the best use of available line capacity, rolling stock and train crews.

As usual with computers, the main problem to be solved is that of logical definition of the technical operating factors involved—track-running facilities, loop lines, junctions, headway, priority of one class of train over another, etc.

If successfully applied, the computer will greatly ease the half-yearly time-table revisions, accelerate the timing of special trains, and give economies from an improved time-table plan.

625-Line Transmissions on U.H.F.

THE British Broadcasting Corporation started, on the 5th May 1958, a second series of high-power experimental television transmissions on u.h.f. in Band V (610–960 Mc/s) from Crystal Palace.

The first series of tests, which ran from November 1957 to the end of March 1958, used the British 405-line standard, the same programme being transmitted in Band V as in Band I, so as to provide a direct comparison.

The present tests, which will continue for three months, are using 625 lines, and the results will be compared with those obtained in the recent 405-line tests. It is hoped that these tests will throw light on the problems which would be encountered if it were decided to use the 625-line standard for a television service in Band IV and V.

The experimental transmissions are using frequencies of 654·25 Mc/s (vision) and 659·75 Mc/s (sound) and are in black and white only.

A number of experimental receivers are being employed and several interested organizations, both public and industrial, are making a study of the received pictures.

SOME NOTES ON THE DEVELOPMENT OF ELECTRIC TRACTION

631.331:625.1

The progress of the railway is traced from its beginning in the Industrial Revolution, through the golden age of the steam locomotive to the recent intensive development of electric traction, which may well raise rail transport to its previous supremacy. Mr. Collins describes the various methods of electric traction, with special emphasis on the Diesel-electric locomotive. The article is based on the author's Chairman's Address to the Irish Branch, which was delivered in Dublin on the 17th October 1957.

L. COLLINS, B.E., B.SC., MEMBER

Class A 1200 h.p. Diesel-electric locomotive of Córas Iompair Éireann

A LITTLE more than a century ago the first phase of the Industrial Revolution, often referred to as the 'canal period', was coming to a close. The growth of coal-mining, the rise of the chemical, metal and engineering industries and the application of machines to the textile industry created a demand for better transport facilities, and this period is characterized by an improvement in roads and inland waterways.

There were, however, other developments to come, which were to cause profound social, economic and political changes. Advances in science and engineering led to the expansion of industry and to the growth of an urban society provided with many new benefits. Prominent among these were railways and electricity, and it may be of interest to recall their early beginnings.

Each was associated with an outstanding personage in the history of engineering—railways with George Stephenson and electricity with Michael Faraday. At first there was little connection between the two, but it is interesting to note that momentous discoveries in both fields were made almost simultaneously.

In 1825 the first public railway was opened between Stockton and Darlington, an event followed in 1830 by the inaugural run of the first passenger-carrying train between Liverpool and Manchester. These two events introduced a new era in transport and marked the beginning of the second phase of the Industrial Revolution.

In 1831 Faraday announced to the Royal Society his discovery of electromagnetic induction and thereby founded electrical engineering, which was later to make its own contribution to rail transport.

From the start, railways forged rapidly ahead and, until the development of the internal-combustion engine, were unrivalled in inland transport. This pre-eminence was largely due to the excellence of the designs produced by Stephenson and the early locomotive builders, and in spite of later improvements the steam locomotive has remained essentially the same as originally conceived. For the first fifty years of railway history it held undisputed supremacy, and until recently it maintained its position as the principal form of railway motive power.

The Start of Electric Traction

Faraday's discoveries took longer to develop, and it was only in the sixties and seventies of the last century that electric power and telecommunication were established. The application of electricity to traction followed shortly afterwards. In 1879, the first electric railway was demonstrated in Berlin, and nearer home an electric tramway was installed in Armagh in 1883. Since then there has been a constant endeavour to further the application of electricity to transport.

Tramway systems met with immediate success, and at the beginning of this century, although the electric motor had not yet reached a high level of perfection, electric trams soon displaced the horse-drawn bus and were being introduced in cities all over the world.

In railways, however, conditions were different. The steam locomotive had reached an advanced stage of development and was well established; traction motors of high power had yet to be developed; voltage limitations and the high cost of electrification discouraged electric operation. Only in special circumstances, where conditions were unusually favourable, did electric traction make any headway. In underground systems the cleanliness of the electric vehicle enabled it to displace the steam locomotive. The older form of motive power also gave way on suburban systems in densely populated areas and on steeply graded main-line systems with heavy freight traffic. In certain countries an absence of coal combined with an abundance of hydro-electric power encouraged further expansion, but this was due to national and political rather than to economic considerations.

From about 1900 railway electrification proceeded at a steadily increasing rate but did not seriously compete with steam until very recently. It was the Diesel locomotive employing an electric transmission system which first threatened the supremacy of steam, and from 1940 onwards this form of traction developed at a very rapid rate. Recent developments indicate that over the next few years there will be a correspondingly rapid expansion in straight electrification.

Apart from battery vehicles, the electric traction machine is not a true locomotive. External power is used, and energy is supplied to the train either by means of a third rail or through overhead wires. The return circuit is usually provided by the running rails suitably bonded at the joints or, as on the London Underground, by a second insulated conductor rail.

For third-rail systems the voltage is low, seldom exceeding 600 volts. Overhead wires are used for d.c. systems of up to 3 kV or for a.c. systems of much higher voltage.

D.C. Traction Motors

Since electric tramways came into being before the advent of a.c. supply, it was inevitable that the first electric railways also should use direct current. Power, generated at relatively low voltages, was fed directly to the track network. With the introduction of a.c. supply, about 1900, generation in central stations became possible, and power was distributed to sub-stations equipped with motor-generator sets or rotary convertors for the d.c. traction supply.

With the machines then available, voltages were limited to low values, and the substations were closely spaced to avoid excessive voltage drop; as a result most of the early traction systems were confined to suburban lines. Later improvements in the d.c. machine allowed voltages to be raised to the present limit of about 3000, this advance being helped by the introduction of the mercury-arc rectifier, which ultimately replaced the rotary convertor in the substation installations. With the higher voltages, main-line electrification became economically attractive, and, whereas the early suburban systems mainly employed motor-coach sets with motors of moderate power, the main-line schemes called for locomotive-hauled trains and for traction motors of much higher rating. The d.c. series motor has a torque/speed characteristic which is ideal for traction purposes and was generally used. Control systems were based on the use of resistances to limit starting currents and on the use of series-parallel connections and motor-field weakening for speed control.

Owing to the need to provide both a high-voltage a.c. transmission system and a medium-voltage d.c. track system, the first cost of the d.c. system was high. Attention was therefore directed to the use of a.c. systems operating at higher voltages.

Three-Phase A.C. System

First to be employed were the three-phase systems based on the robust and simple three-phase induction motor, which had already been developed for industrial applications. Speed control was effected by pole-changing and cascade connection. Current was collected from two overhead wires, and the track was used for the third phase. Usually the line voltage did not exceed 3000 volts, but this was several times greater than the direct voltages then possible.

It was not then considered feasible to use regenerative braking on d.c. systems, and the possibility of regenerating power on downgrades was considered to be one of the main advantages of the three-phase a.c. system. This system was used on the Swiss mountain railways, the first line being opened in 1899. From 1902 to 1910 several main-line sections in Northern Italy were electrified, and many of these retained the three-phase system until the nineteen-fifties. To improve motor performance, a low frequency was adopted, and the opportunity was thereby lost of securing the advantage which three-phase power at normal frequency has over the d.c. and single-phase systems. The development of regenerative control, together with the use of the series motor in the d.c. and single-phase a.c. systems, eliminated any advantage possessed by the three-phase system. Its development therefore ceased, and it was later generally abandoned.

Single-Phase A.C. System

The single-phase a.c. system took longer to come into use, since it was not until 1910 that a suitable traction motor became available. Initially several types were experimented with, but the series-compensated motor, like the d.c. series machine, has proved the most suitable.

The early motors were large low-speed machines driving the axles through various forms of rod and gear transmission, and it was not until 1940 that sufficiently compact motors were developed to enable individual axle drives to be employed. After that date the individual axle drive, which had for many years been standard on d.c. systems, was generally adopted on single-phase locomotives, and the use of side-rods was abandoned.

Because of motor commutation difficulties the early single-phase systems used low frequencies. In places where 25 c/s supply had been adopted for commercial systems, the contact wire was sectionalized and fed from individual phases of the polyphase system. In most cases, however, it was necessary to generate single-phase power for the traction load, and for many of the early schemes a frequency of 15 c/s was adopted. later, when it became usual to take power by phase- and frequency-conversion from the commercial three-phase supply, a frequency of $16\frac{2}{3}$ c/s was adopted for traction. This frequency was easily obtained by single-phase alternators driven by motors fed from the normal 50 c/s supply.

Since both the d.c. and three-phase a.c. systems were restricted to low voltages—the former because of the limitations of the d.c. motors and the latter because of the need to use two overhead contact wires—the single-phase system possessed the great advantage that the contact voltage could be increased to high values, and voltages up to 22 kV were ultimately employed. This permitted the substations to be spaced considerable distances apart and thereby reduced the cost of track electrification. In countries with extensive railway systems, but without populous cities, which would have encouraged the development of d.c. suburban systems, the single-phase system became particularly attractive. Also the use of low frequency, suitable for hydraulic turbine drives, encouraged its adoption in countries with abundant hydro-electric power. For both these reasons extensive application of this form of railway electrification took place in countries such as Sweden and Switzerland.

As the single-phase traction motor is inherently a low-voltage machine it is necessary to use transformers mounted on the power unit to supply the motors at a suitable voltage

Motor-speed control is provided by tapping the step-down transformer. There is, therefore, no series resistance as in d.c. control systems, and each controller notch is a running position on which the motor may be operated for any required period. Regenerative or rheostatic braking can be arranged by suitably exciting the traction motors to run as generators.

Progress of Electrification and Advent of the Diesel Engine

Both the a.c. and d.c. systems, in following the developments so far briefly outlined, expanded at almost equal rates, and the total mileage of electrified track is now divided between them almost equally. Nevertheless, the impact of railway electrification, except in a few countries, has not been great, and of the 780 000 route-miles of railways in the world to-day, only 30 000, or a little less than 4%, are electrified.

The development of road transport since the twenties destroyed the monopoly position held by railways and provided an increasing threat to their survival as an economic form of transport. Railway administrations have therefore been forced to search for more economical methods of working and more efficient forms of motive power, not only because of the very low thermal efficiency of the steam locomotive but also because of the increasing cost of solid fuels.

Since Stephenson's day, the total efficiency of the steam locomotive under optimum conditions has increased from 4% to 12%, but for average conditions an efficiency of about 7% is representative of modern practice. For the electric locomotive, measuring the energy from the fuel source to the wheel rim, the corresponding figure is between 15% and 20%. This wide difference in efficiency and consequent reduction in fuel costs was not sufficient to outweigh the high initial cost of electrification, and the expansion of electric traction was slow.

The Diesel engine, however, has a very high thermal efficiency—approaching 40%—and, allowing for power losses in the transmission system, overall operating efficiencies of about 27% are possible. The potential economy in fuel costs and the absence of expenditure on track installations encouraged railway engineers to explore the possibility of using this highly efficient power unit as a substitute for steam.

There were, however, many difficulties to be overcome, and I can do no better than quote Dr. Diesel, who in 1911 said:

> The problem of the Diesel locomotive is certainly the most difficult task which could have been laid on the shoulders of designers, not only because of the problems of the engine itself with the enormously intricate problems of starting and manoeuvring, but also because of the extraordinary restrictions in space and weight.

The two main difficulties referred to by Dr. Diesel of devising a suitable transmission system and reducing the specific weight of the Diesel power unit took many years to overcome. The latter difficulty is outside the scope of this article, and I will therefore deal only with the transmission problem.

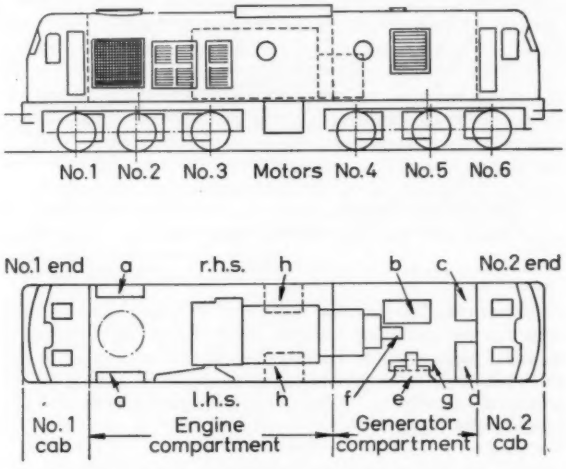
Early attempts were made to adopt the direct drive of steam locomotive practice, but, since the Diesel engine is not self-starting and cannot develop torque at zero speed, some form of transmission is necessary. This must be capable of disconnecting and reversing the drive and converting the fixed speed and torque of the engine to a varying speed and torque at the axle to meet the traction effort requirements from rest to full speed.

Owing to power limitations it was not possible to adopt the simple mechanical transmission employed by road vehicles, and the early designs of hydraulic, pneumatic and other transmissions were not successful. It was inevitable that electric transmission should be considered, and in 1925 a Diesel-electric shunting locomotive of 300 h.p. was put into service in the United States. This unit, which is still in service, was followed by many others for shunting duties, but it was not until 1940 that main-line Diesel-electric locomotives for freight and passenger working came into general use.

The development of d.c. traction had resulted in the production of reliable traction motors and control gear, but there were other problems to be solved in applying electric transmission to Diesel locomotives.

The Modern Diesel-electric Locomotive

The Diesel-electric locomotive consists essentially of an electric locomotive which embodies its own power-generating plant, as shown in Fig. 1. Since there is no distribution



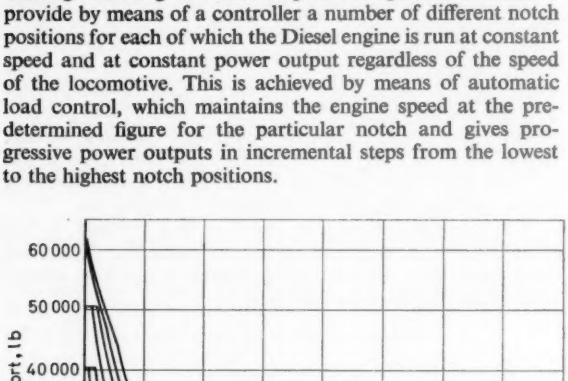
1 *Diagram of a Class A 1200 h.p. Diesel-electric locomotive*

a Radiator panels.
b Load regulator.
c H.V. electrical cubicle.
d L.V. electrical cubicle.
e Pressurizing fan.
f Compressor.
g Exhauster.
h Battery.

problem, the question of voltage is not critical, and, owing to its many advantages with respect to the traction motor, direct current is the obvious choice.

The equipment consists, therefore, of a Diesel-driven d.c. generator feeding power to traction motors of medium voltage. In contrast to straight electric systems drawing power from a constant-voltage source the Diesel-electric unit obtains its power from a constant-power source, the magnitude of which is determined by the continuous rating of the Diesel engine. For this reason a special form of load control has been developed which ensures that the full rated power of the engine can be utilized over the full range of locomotive speed and which also ensures that the engine is at no time loaded beyond its capacity. To provide for traction

loads below the rated capacity of the engine and to provide speed control of the locomotive, the control system can be set to give a range of different power outputs. It is usual to provide by means of a controller a number of different notch positions for each of which the Diesel engine is run at constant speed and at constant power output regardless of the speed of the locomotive. This is achieved by means of automatic load control, which maintains the engine speed at the predetermined figure for the particular notch and gives progressive power outputs in incremental steps from the lowest to the highest notch positions.



2 *Performance diagram*
Class A 1 200 h.p. Diesel-electric locomotive.

For any notch position the speed of the engine is kept constant by governor control, and the power output is similarly maintained at the designed figure by regulating the fuel rack position to give constant torque. The engine power and speed data for a 1 200 h.p. Diesel-electric locomotive are given in the Table.

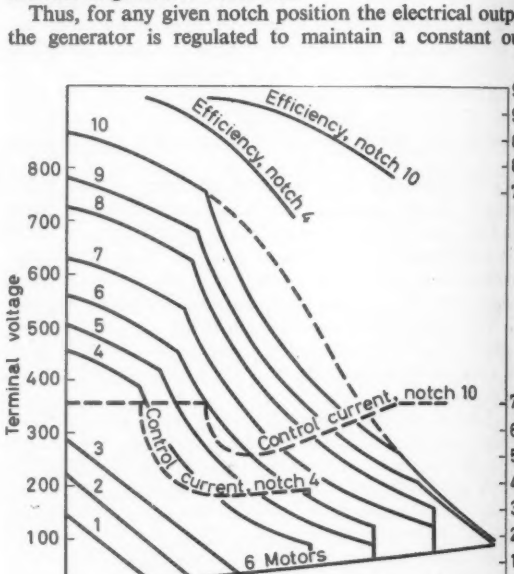
Performance data for a Class A 1 200 h.p. Diesel-electric locomotive

Notch	Regulated engine power		Speed
	Total	Traction	
	h.p.	h.p.	r.p.m.
1	—	—	346
2	—	—	339
3	—	—	333
4	375	315	328
5	490	430	363
6	612	552	403
7	753	693	456
8	915	855	523
9	1035	975	563
10	1200	1140	625

Since, for any notch position of constant power, the power output at the wheel rim is determined by the product of tractive effort and locomotive speed, the characteristic curve of tractive effort plotted against locomotive speed is a hyperbola. Fig. 2 shows a set of such curves for a 1 200 h.p. Diesel-electric locomotive. Similarly, the product of voltage and current from the generator should also be constant, and the ideal generator output characteristic is also a hyperbola, as shown in Fig. 3.

To achieve this characteristic curve, machines having various combinations of external excitation, shunt excitation and series decompounding are employed. To match the generator output exactly with the Diesel engine output, a form of load control has been developed which relates the strength of the field excitation to the position of the engine fuel rack. A servo mechanism operates in such a manner that any tendency of the engine fuel rack to exceed the correct load position reduces the excitation of the generator, which in turn reduces the load on the Diesel engine and allows the fuel rack to return to the proper position. Any tendency to off-load the engine is countered in a similar manner by an increase in generator excitation.

Thus, for any given notch position the electrical output of the generator is regulated to maintain a constant output



3 *Generator-output characteristic curves*

Class A 1 200 h.p. Diesel-electric locomotive.
Resistances at 110° C: armature + interpole + series = 0·0205 ohm; control winding = 1·44 ohm; external notch 1 = 9·21 ohm; notch 2 = 5·51 ohm; notch 3 = 3·31 ohm; notches 4–10 = 0·1 ohm minimum and 3·31 ohm maximum.

from the Diesel engine. This system of automatic load control is now universally employed for main-line locomotives, but there are differences in the detail designs adopted by different manufacturers. For shunting locomotives it is not always considered desirable to incur the cost of automatic load regulation, and less complex systems are employed.

It is not necessary, as with d.c. straight electric traction, to regulate the voltage on the traction motors at starting and

low speeds by means of resistors or by means of different motor groupings. Instead, the voltage of the main generator is regulated by means of the notch position and the automatic load regulator to give the required characteristic.

An engine-driven auxiliary generator provides the separate excitation for the main generator. This machine, maintained at a constant voltage by means of an automatic regulator, supplies power for the control circuits, motor-driven fans, pumps, exhausters, compressors, etc., and is also used to charge the battery. The battery supplies power to certain auxiliary equipment when the engine is not running, that is, before starting and after shut-down, but its main function is to start the engine by motoring the main generator.

The control gear is of very robust construction and is built to normal traction standards to withstand vibration and arduous duty.

The traction motor design follows the practice established by many years of electric traction. The motor is supported at one end by what is called *nose suspension* from the bogie frame and at the other by sleeve bearings in which the locomotive axle rotates. The motor bearings proper are usually of the ball- and roller-bearing type, and the drive is transmitted by means of a pinion on the motor shaft driving a gear-wheel on the locomotive axle.

Because of the wide fluctuations in tractive effort, both the main generator and traction motors have to withstand heavy currents, particularly at starting, and it is usual to specify short-term current ratings. To withstand the considerable temperature rise associated with these short-term ratings, Class B insulation is used for traction motors, and forced ventilation is employed.

The generator and motors are also given a continuous rating dependent on the maximum current at which they can be operated within the safe temperature rise. This rating fixes what is known as the continuous tractive effort, and on long stretches of steeply graded line it may fix a limit for the tonnage rating. Normally, owing to the very high starting tractive effort of the Diesel-electric locomotive, the tonnage rating is limited only by adhesion and by the desired rate of acceleration. It is now quite usual in Canada and the United States to haul freight trains of up to 6000 tons using four Diesel-electric locomotives in multiple.

After the dramatic change-over from steam to Diesel traction in the United States, which began in 1940 and which is now almost complete, many countries followed the American example. The construction of steam locomotives throughout the world declined and has now almost ceased. Until quite recently, therefore, it seemed that, in spite of increasing interest in straight electrification, the further development of railway motive power would be based largely on Diesel traction.

I should mention at this stage that the electric system of transmission has within the past few years been rivalled by the development of the hydraulic drive, particularly in Germany, and it appears that there will in future be a parallel expansion of both systems. It is too early yet to assess the future potentialities of gas-turbine locomotives and locomotives using nuclear fuels, but development work is proceeding in both these fields.

Recent Developments in Straight Electric Traction

In order to complete the picture in regard to electric traction it is necessary to consider the latest developments in straight electrification. It has already been mentioned that electrification to-day covers less than 4% of the track mileage throughout the world.

There is, therefore, a very wide field for the further expansion of railway electrification, and it was generally accepted in the post-war years that electrification could play a major part in improving European railway systems. In the reconstruction of the railway networks after the war, many countries such as Britain, France, Belgium, Holland and Italy proceeded to electrify large sections using d.c. systems at either 1500 or 3000 volts. Countries which had adopted low-frequency single-phase traction, such as Switzerland, Germany, Austria, Sweden and Norway, also extended their electrified lines.

French and German Experiments

In 1950, as an experiment, the French railways introduced 50 c/s single-phase traction on a short section of line in the Savoy Alps, and this development marked the successful culmination of many efforts to use commercial frequency for a.c. traction systems. As early as 1923, experiments with 50 c/s supply using the Kando system were begun in Hungary, and in 1933 this system was adopted for a section 119 miles long from Budapest to the frontier. Single-phase current at 50 c/s and 16 kV was supplied to a rotary convertor on the locomotive, which supplied three-phase power to the traction motors. The next development using commercial frequency for a.c. traction took place in Germany in 1936, when four experimental locomotives were built for a short section of track in the Black Forest, using a single-phase 50 c/s supply at 20 kV. Two of the locomotives were equipped with mercury-arc rectifiers and d.c. motors, with different systems for controlling the d.c. voltage; the third was equipped with an adaptation of the Kando system using phase convertors and three-phase motors; and the fourth was equipped with 50 c/s single-phase series traction motors.

In the French experiment three locomotives were ordered—two with different designs of 50 c/s motors and the third with a rotary convertor and d.c. traction motors. Some months previously the Pennsylvania Railroad had introduced a motor-coach equipped with d.c. motors supplied through ignitron single-anode rectifiers on its 11 kV 25 c/s single-phase system, and this directed attention in the United States to the possibility of using industrial frequency as an alternative to the existing low-frequency system and to Diesel-electric operation, which had in some instances caused electrification schemes to be abandoned. It appears likely that in the near future locomotives using ignitron or germanium rectifiers will be preferred to locomotives with rotary convertors or 50 c/s traction motors. However, technical improvements in traction motors and conversion systems are occurring so rapidly that the future line of development is not too clearly defined.

It is certain, however, that the advantage of tapping the national Grid system and the lower cost of electrification using industrial frequencies will lead to a further expansion of a.c. traction and a considerable increase in railway electrification throughout the world. Further developments with 50 c/s traction have already taken place in France, Turkey and the Belgian Congo, and British Railways have announced their intention to adopt it for the electrification of their railway system.

The age of the steam locomotive is passing, and it has taken over sixty years of experiment and progress to establish electric traction as a worthy successor.

GEORG SIMON OHM AND HIS LAW

621.3.011.1

An editorial footnote led Ohm to his best work. This article, by a member of the Department of Engineering, University of Cambridge, may lead readers to a greater interest in a man whose name is a household word but whose work, apart from his 'law', is little known.

P. HAMMOND, M.A., ASSOCIATE MEMBER

Georg Simon Ohm

'Do you understand Ohm's law?' A few years ago I should have answered, 'Of course I do, it's schoolboy stuff'. But that was before I had to explain Ohm's law to other people. To have to explain things is an excellent way of finding out how little one knows; I had to confess that I did not even know what Ohm's law was. The various authorities I consulted shared my vagueness on the matter. To some, Ohm's law was a definition of the term resistance (equal to potential difference divided by current). But to call a definition a law seemed hardly sensible. Other writers distinguished between ohmic and non-ohmic resistance, and thus Ohm's law was to be taken as an experimental discovery of the constancy of the resistivity of metals at constant temperature. Finally I decided to consult Ohm himself, and after searching through many old and obscure journals I found a copy of Ohm's collected works.* The pages were uncut. So also were the pages of Faraday's and Cavendish's works which I came across. Apparently the Antarctic is not the only unexplored region.

Early Years

Georg Simon Ohm was born in 1789 in the Bavarian town of Erlangen, the son of a locksmith. That was two years before the birth in London of Michael the third child of James Faraday, blacksmith. Georg and his younger brother Martin early showed great intelligence. Father Ohm was exceedingly fond of mathematics, and his boys came to share his enthusiasm. Their education was altogether better than that of Michael Faraday, and an academic career was the ambition of both the boys. Georg left the local grammar school (*Gymnasium*) at the age of 16 and entered the University of Erlangen. But after 18 months there he took a teaching appointment at a private school in Switzerland. He returned to the university at the age of 20 and spent four years there, obtaining his doctorate in two years and then spending two years as a research fellow (*Privat-dozent*). But academic preferment was slow in coming, and he accepted an appointment at a secondary modern school (*Realschule*), where he stayed for four years and published his first paper on 'Geometry as a Means of Education'. Perhaps as a result of this paper, he obtained the post of senior mathematics and physics master at the grammar school at Cologne.

It was an important post for so young a man, but it did not satisfy Ohm. An academic career was the family ambition, and his younger brother had become a successful professor of mathematics at the military academy in Berlin. More and more, Ohm's thoughts turned to research, and in his spare time he began to experiment with current circuits containing electric batteries or, as they were then called, 'galvanic chains'. In 1825, at the age of 36, he published his first important paper in this field. He used a copper/zinc cell and obtained an experimental relationship for the decrease in current strength ΔI when a variable length x of conductor was inserted in the circuit. The law he gave was:

$$\Delta I = m \log \left(1 + \frac{x}{a}\right)$$

where m and a are constants.

On the basis of Ohm's law (!), he should of course have found that $\Delta I = mx/(a + x)$. Every schoolboy could derive this result, but in 1825 nobody expected it or knew it. The only person who had known it had died 15 years before, and had told nobody else about his knowledge. That was the Hon. Henry Cavendish, who had made Ohm's experiments in 1781 using condenser instead of batteries and his own sensitivity to electric shock instead of a galvanometer, and had obtained the correct result.

Poggendorff's Suggestion

It was an editorial footnote, surely one of the most important footnotes in the history of science, that

* LOMMEL, E. (Ed.): 'Gesammelte Abhandlungen von G. S. Ohm' (Leipzig: Johann Ambrosius Barth, 1892).

showed Ohm his mistake. Poggendorff, the editor of the scientific journal in which Ohm's paper was published, suggested in this note that the author should try to repeat his experiments using a thermocouple rather than a battery, because its effect would be far more constant. Ohm took the advice, and a year later he published two classic papers giving the correct form of his law, having clearly understood that his previous experiments had been made useless by polarization effects in the battery. He gives two laws:

$$I = \sigma \frac{a}{l} E \quad . \quad . \quad . \quad . \quad . \quad (1)$$

and

$$V_x - C = \pm \frac{x}{l} E \quad . \quad . \quad . \quad . \quad (2)$$

where I is current, σ conductivity, a cross-sectional area of conductor, l total length of conductor, x a variable length along the conductor, E the 'electric tension', V_x the electroscopic force* (or electricity) at x, and C a constant. Ohm did not claim to be the originator of the first law, which had, as he knew, been foreshadowed by Davy and others, and unknown to anybody had been proved by Cavendish, but the second law he regarded as his very own. Actually even the first law owed much to him, because he was able to combine in a simple equation all the scattered numerical results of Davy.

It was Ohm's strong point, and also his weakness, that he readily formulated equations to fit his experimental data. At his first attempt this method had led him astray, but Poggendorff's advice and his own skill and patience as an instrument-maker and experimenter had led to brilliant success. Ohm was confident that a professorship was within his grasp, but before he applied for such a position he wanted to show his skill as a theoretical physicist. He obtained leave of absence from his teaching post and spent a year in the preparation of his *magnum opus*—a mathematical theory of current flow leading to a theoretical proof of his two equations. It was published in 1827: an enormous monograph of 126 pages, of which 42 pages were headed 'Introduction'. It was the zenith of Ohm's career, and the preface to the work announced his intention of further papers which should form a complete theory of electricity. A copy of the work was dispatched to the Prussian Ministry of Education. With it went a letter of resignation of his post at Cologne and the hope for a more suitable appointment.

'An Incurable Delusion'

Ohm awaited a favourable reply. When the reply came, there was in it nothing but the offer to do some coaching in mathematics in connection with the artillery school in Berlin. It was a slap in the face, and Ohm, who had always been reserved and difficult, became bitter. He could never stand criticism—few of us can—and some of the reviews of his work were destructively critical. A certain G. F. Pohl wrote of his great work: 'He who looks on the world with the eye of reverence must turn aside from this book as the result of an incurable delusion, whose sole effort is to detract from the dignity of nature.'

The trouble was that Ohm had by his experimental approach incurred the displeasure of the disciples of the philosopher Hegel, and Hegelian philosophy was at that time supreme in the academic institutions of Germany. However, Ohm was not without influential friends, and among them were the editors of several scientific journals who continued to publish his writings. But he felt that even they were against him when they urged self-restraint and asked him to refrain from bitter public controversy.

For six years Ohm remained in the wilderness acting as a private tutor in Berlin, but he also enlarged on his work and tested and applied his beloved equations in every possible way. He developed what are now known as Kirchhoff's equations, and his works form a compendium of examination questions on parallel and series circuits. But throughout his writings he never allows the reader to forget his personal sufferings. Ill-health, the cold winters, lack of tools and access to books, a draughty attic, unfriendly critics, people in high society who despise his humble parentage—all conspire against him. A comparison with the early struggles of the blacksmith's son Michael Faraday comes to one's mind. But Faraday had spiritual resources to which Ohm appears to have been a total stranger, even if in one of his papers he calls down Heaven's blessing on his work.

In 1833 Ohm's fortunes improved with his appointment as professor at the technical college at Nuremberg. In 1841 he was awarded the Copley Medal of the Royal Society, of London, and this honour touched him deeply. He writes that this 'mark of approbation renewed his failing courage to engage in further battles on the field of knowledge'. In 1844, at the age of 60, Ohm's ambition to occupy a professorial chair at a university at last came true. He was appointed professor of physics at Munich. He died five years later.

His Essential Discoveries

Although Ohm wrote on optics and geometry and published a highly important paper on sound waves, his chief interest lay with the theory of the 'galvanic chain'. His general theory of electricity was never written, and he is essentially 'Ohm of Ohm's law'. What exactly was it that he discovered?

First, he rediscovered that electricity flows uniformly throughout the volume of a metallic conductor. This is shown by the fact that the cross-sectional area enters into his equation. Secondly he rediscovered that the conductivity (or resistivity) of metals is constant at constant temperature. These immensely important discoveries he expressed by his first equation.

But unlike most of his successors Ohm went further than this. He set himself the question as to the seat of the forces that propel the current along the wire. It seemed

* The meaning of this term is discussed towards the end of the article.—Editor.

to him obvious that the particles of the conductor could act only on immediately adjacent particles. The electricity on the plates of the battery could act only on the pieces of wire adjoining these plates. It became necessary to suppose that all along the wire there must be an additional distribution of electricity. Ohm carefully distinguished between the transient condition when this distribution was altering, for instance on first connecting the circuit, and the steady-state condition when the current was propelled by a steady charge distribution. Ohm called this charge distribution the electroscopic force, and he measured it by bringing a proof plane in contact first with the conductor surface and then with an electroscope. In our language he measured the potential (above some arbitrary value) by this means. This led him to his second equation.

Unfortunately, Ohm's definitions are far from clear. At times he seems to suggest that the electroscopic force is what we should now understand by electric force, while at other times it seems to be what we should call volume charge density. In this confusion he falls back on Fourier's theory of heat conduction published in 1822. His experimental results fit Fourier's equations, if electroscopic force is made analogous to temperature. So Ohm was able to make use of Fourier's results, and he showed, although unknowingly, that the mechanics of electric conduction are those of a highly viscous flow and that electric force is proportional to the velocity of the flow. (This, too, may have been known to Cavendish, who refers to the current as the 'velocity'.)

Electrostatics Teaching

Ohm's theoretical derivation of his law does not carry conviction. He seems completely ignorant of the inverse square law of force between electric charges. He quotes French authors and was evidently able to read French, although he had to read English in translation, but he was apparently not even familiar with Coulomb's verification of the inverse square law. It almost seems that he read nothing except strictly contemporary work. Possibly his lack of access to books is to blame. Thus his attempt at a theory of the current flow was almost bound to fail.

With his law we have also inherited his confusion, a confusion that is perpetuated by the lack of teaching of electrostatics, so that the unfortunate student meets first electromotive force and then electric force. After 130 years we are still far from a theory of current flow and the existence of a charge distribution to drive the current, which was recognized by Ohm, is almost always ignored. But this charge distribution, too, is part of 'Ohm's law'. Ohm may have been confused, but he knew more than many textbooks of the present day.

'Schoolboy stuff?' Well, it depends on the schoolboy.

THE CHESTERS ESTATE

Some new photographs of The Institution's homes for members and their dependants

To walk round the Chesters Estate at New Malden, Surrey, is a delightful and surprising experience. Only those who have seen it can realize how attractive it is. The estate comprises sixteen houses and flats on a site of about six acres, which was presented by Mr. C. W. Speirs to The Institution's Homes Fund some twelve years ago. Homes are made available by the Governors of the Fund to retired or crippled members of The Institution and their dependants who have fallen on hard times. The houses are let either at a nominal rent or rent-free.

The Chesters Estate is beautifully laid out, with open lawns, trees and flower beds. Most of the houses are detached and are carefully sited in relation to each other. The layout and design have been in the capable hands of the distinguished architect, Mr. Louis de Soissons. He has made little, if any, concession to post-war trends in architecture, and many people are pleasantly surprised at finding sash windows and front doors with curved glazing bars in houses built in the nineteen-fifties. However feelings may vary about this, few would dispute that the estate is one of the most successful built since the war.

The photographs shown opposite were taken last autumn and have not previously been reproduced. At the top of the page is a view of some of the houses on the newer part of the estate, and beneath may be seen the staircase leading from the hall in this type of house. Next to this is a view of the gardens of two older semi-detached houses. The photograph at the bottom right shows the Warden of the estate, Mr. H. Nunn, and Mrs. Nunn in the sitting-room of their charming house, which has a fine view over the Malden Golf Course to the Surrey hills. Mr. Nunn was for many years Head of the Membership Department of the Secretary's staff in London and now works part-time in managing the affairs of the Benevolent Fund. He will be very pleased for any member of The Institution to visit the Chesters Estate, and anyone interested should write first to the Secretary at Savoy Place, to say when he would like to come.

THE CHESTERS ESTATE
A LIVING MEMORIAL
TO COMMEMORATE THOSE MEMBERS OF THE
INSTITUTION OF ELECTRICAL ENGINEERS
WHO GAVE THEIR LIVES FOR THEIR COUNTRY
AND IN THE CAUSE OF FREEDOM DURING THE
WAR OF 1939-1945
The estate was presented by C.W. Speirs J.P. M.I.E.E.
of the funds for its development subscribed by
members of The Institution

The History of Electrical Engineering

8. THE EVOLUTION OF THE CENTRAL STATION

From the successful development of the incandescent lamp, described in the last article in this series, the author now turns to the early ventures in electricity supply to public and private consumers.

C. MACKECHNIE JARVIS, MEMBER

By about 1885, following the general availability in this country of the Gramme and Brush dynamos, electrical illumination by means of the carbon arc lamp had become practicable, and the 'subdivision of the electric [arc] light', which had been regarded as a 'will o' the wisp' by Sir William Preece and some of his equally celebrated contemporaries, had become a reality. Incandescent filament lamps had graduated from the stage of laboratory experiment to a position of potential importance in the domestic sphere.

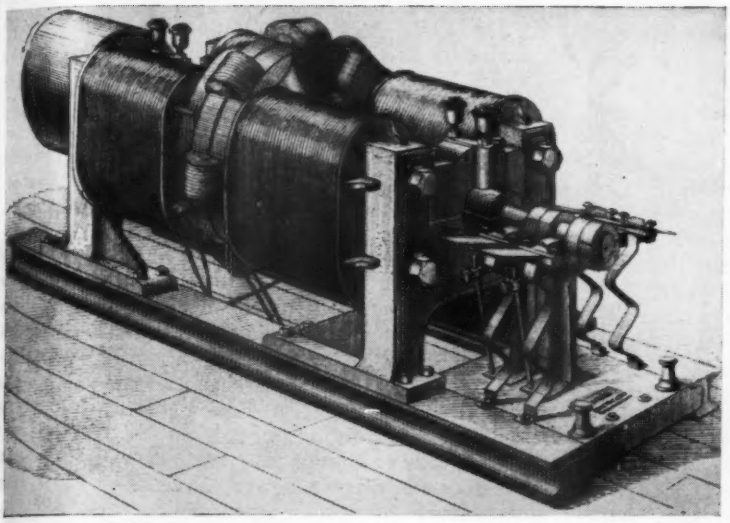
It had been proved that direct-current energy was not indispensable and that for most forms of the arc lamp and for incandescent lighting alternating currents were equally suitable, and in fact, for the Jablochkoff candle type of arc lamp, essential. Some relatively large alternators had been manufactured by J. E. H. Gordon in this country in 1882 and by the Hungarian firm of Ganz on the Continent. In the United States alternating-current technique developed much more slowly, and at first its only prominent advocate was George Westinghouse (1846–1914), famous as the inventor of the vacuum brake. Matters arose in this way: in 1884 Westinghouse, at that time the head of a powerful organization, the Union Switch and Signal Co. of Pittsburgh, was introduced to William Stanley, an electrical engineer seeking to exploit a self-regulating dynamo, an incandescent lamp and other inventions. This meeting coincided with a growing interest on the part of Westinghouse in the future of electric lighting, and it was agreed that Stanley would join the company to take charge of electrical developments.

'*Pure Humbug*'

In 1885, an account of the London Inventions Exhibition of that year reached Westinghouse, and from it he first learned of the proposals afoot to establish high-voltage transmission using Gaulard and Gibbs transformers. Guido Pantaleoni, a member of the Pittsburgh staff, was on leave in Italy, and Westinghouse cabled instructions that an option on the patents of Gaulard and Gibbs was to be secured. After discussions with the patentees, Pantaleoni found it difficult to assess the practicability of such a system and sought the opinion of Dr. Werner Siemens, who told him that there was 'nothing whatever in alternating currents', that it was 'pure humbug' and that Siemens' own 5-wire system had rendered alternating currents useless. Fortunately for Westinghouse, Pantaleoni had discussions with the firm of Ganz of Budapest, with whom were associated the distinguished engineers O. T. Bláthy (1860–1939), M. Déri (1854–1938) and K. Zipernowski (1853–1942). This concern, he found, strongly supported the use of alternating current and was in fact experimenting with transformers in parallel. On the strength of Pantaleoni's report, Westinghouse decided to develop an a.c. system, notwithstanding strong opposition from his colleagues at Pittsburgh.

Before the end of 1885, Westinghouse was in possession of a Siemens alternator and some Gaulard and

George Westinghouse (1846–1914)



Brush arc-light dynamo, c. 1879–80

Gibbs transformers sent from London, and he was joined by Reginald Belfield, an English engineer, who had had operating experience with Gaulard and Gibbs apparatus, presumably on the Grosvenor Gallery installation.

American Pioneers

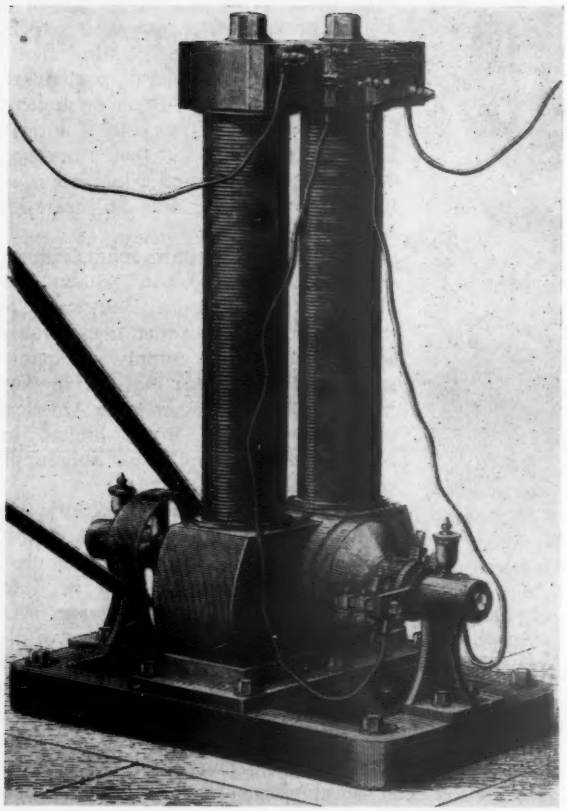
In order to view the decision of Westinghouse objectively, it is necessary to consider electrical development in the United States at this period in some detail. Reference has already been made in an earlier article in this series to the work of the American pioneer, C. F. Brush (1849–1929), who designed and built an experimental dynamo in 1875. Shortly afterwards, Brush obtained the support of the Cleveland Telegraph Supply Co. and by 1878 was in a position to supply dynamos and arc lamps. His machines were made in two sizes, to feed two and four lamps respectively, the lamps operating in parallel and consuming about 9 amp each. This was an obvious advance on the series circuits then in use. A notable early Brush arc-lighting installation, operating in November 1878, was that at John Wanamaker's store in Philadelphia, consisting of five 4-light dynamo sets. In 1879, Brush introduced an automatic voltage regulator on the carbon-pile principle and, about the same time, a twin-carbon long-burning arc lamp.

His system was now enjoying considerable success, but Brush held the view that the greatest potential market was that of public street lighting, and he was at this period prepared largely to discount the value of business obtainable for arc lamps in the private market. On the other hand, he perceived the difficulty of persuading local authorities to dispense with gas and make themselves financially responsible for the generation of their own electricity. Accordingly, he developed a system whereby he promoted the formation of district street-lighting companies, raising local capital and negotiating terms favourable to his company, particularly in respect of the use of Brush equipment. The first of these was the California Electric Light Co. of San Francisco, whose generating station, supplying street lighting exclusively, was in operation during 1879.

In 1880, the name of his manufacturing company in the United States was changed to The Brush Electrical Co., and it thereafter expanded considerably, sponsoring similar supply companies with attendant power stations in New York, Boston and other large American cities. Until 1889, Brush limited his activities to the manufacture and supply of d.c. equipment.

The Thomson–Houston Electric Co. was established at Lynn, Mass., in 1883 and was directed by Elihu Thomson (1853–1937), who was born in Manchester and was taken to America at an early age. With Professor E. J. Houston he worked out a system of d.c. arc lighting, commonly held to be superior to that of Brush, and started manufacture on a small scale in the name of the American Electric Co. in 1881. However, progress was hampered financially, and in 1882 Thomson withdrew his patents in order to start again. It was during this period that development work was done on a 40-light 2 000-volt dynamo whose commutator was swept by an air blast. Another feature of the equipment for street lighting was a lightning arrester, incorporating a magnetic blow-out.

Dr. Elihu Thomson (1853–1937)



Edison's arc-light machine, c. 1879–80

Thomson–Houston equipment was first shown in England at the Inventions Exhibition of 1885, at which it received, after most stringent tests, the only gold medal awarded. The Thomson–Houston Co. followed the practice of Brush in sponsoring the formation of local electric-lighting companies and enjoyed similar success.

Another Englishman, who after emigrating to the United States became prominent in the electrical world, was Edward Weston (1850–1936). After some years of experiments with dynamos, followed by small-scale manufacture, he founded the Weston Dynamo Electric Machine Co. in 1877 (renamed Weston Electric Light Co. in 1879). Weston became prominent in the sphere of electroplating, and low-voltage dynamos supplied for this purpose were particularly successful; he was the first American manufacturer to use a laminated-armature core. In 1882, Weston disposed of his interests to the United States Electric Lighting Co., with whom were associated Sir Hiram Maxim (1840–1916), famous as an inventor, William Sawyer and Moses G. Farmer. Hitherto, this company had been developing Maxim's incandescent lamp, and the merger, with the assistance of Weston, enabled complete d.c. electrical equipments to be supplied.

The Fuller–Wood organization was founded as a subsidiary of the Fuller Electrical Co. of New York, which was established in 1877 to develop the arc-lighting patents of J. B. Fuller. The patents of James Wood were acquired in 1879, in which year the new company was registered. This concern was the least successful of the larger groups and was again the subject of a merger, when in 1885 E. H. Goff acquired an option on the patents. Goff had founded the Hartford Electric Light Co. in 1881 and many others in subsequent years. At one stage in his career, he absorbed as much as 20% of the total output of the Thomson-Houston Co., but by 1885 he was manufacturing d.c. equipment on his own account, largely for sale to his own undertakings.

The last of the powerful American companies to be considered is that of T. A. Edison (1847–1931) founded in 1878 as the Edison Electric Light Co. This organization, directly or through subsidiaries, made and supplied dynamos and lamps and followed the general pattern of development in the United States by sponsoring the formation of local lighting companies for the consumption of Edison d.c. equipment.

Against such a background of direct-current practice, the boldness of the decision of Westinghouse to develop an alternating-current system becomes apparent.

'*Remove the Buzz*'

Meanwhile, in England, one of the most active among many pioneer electrical engineers at this period—and one to whom the development of the power-supply branch of the electrical industry owes a great debt—was Robert Hammond (1850–1915), a Member and for some years Honorary Treasurer of The Institution. Originally connected with the iron industry, Hammond carried out his first arc-lighting installation at the Middlesbrough iron works of Bernhard Samuelson and Co. in 1880, and thereafter he carried out many others in industrial premises in the North Country. Early in 1881 Hammond secured important options on the sale in specified English counties of Brush d.c. generators and equipment, which had become popular in America and were now available in limited quantities in Great Britain. About this time, Hammond started to tour England with a mobile steam-engine generating set and gave a demonstration of the new light in many towns and cities.

In October 1881 he established in Chesterfield a public generating station, which he later claimed to be the first in England to supply both incandescent and arc lamps on the same network. The machinery used consisted of a Brush 2 kV 10 amp dynamo, and the load was supplied on a series-parallel arrangement in which a number of incandescent lamps in parallel groups were connected in series with a constant-current arc-lamp circuit. The Chesterfield experiment was continued for some years and provided useful experience for later Hammond stations, especially those of Brighton and Eastbourne.

In 1881 also, he provided electric lighting for the York meeting of the British Association at his own

expense. The President, Sir John Lubbock (afterwards Lord Avebury), among whose many attainments was an expert knowledge of bees, found the noise from the generating plant outside the building distracting and ordered Hammond to 'remove the buzz'. Much to the surprise of those attending the meeting, Hammond was able to move the plant without difficulty and with the aid of longer cables to restore the service after a short interruption.

Hammond's activities attracted the attention of influential financiers, and it is not surprising to find him before long the Managing Director of the Hammond Electric Light and Power Supply Co. founded in 1881. To this company, in consideration for a shareholding of £35000, he had transferred the concessions and options he held from the Anglo-American Brush Corporation,

Robert Hammond (1850–1915)

Among his many achievements was the founding in 1882 of the Hammond Electrical Engineering College, primarily for the purpose of training personnel for the Hammond company and its subsidiaries. For many years the college has been known as Faraday House.

which had been founded in England in February 1881 to develop the European market for the American factories established by C. F. Brush.

The Hammond company successfully launched a series of subsidiaries, to each of whom was granted an absolute licence to develop the generation and sale of electric power within a prescribed territory. These licences transferred in its entirety the substance of the main concession from Brush, which comprised a guaranteed supply of dynamos and equipment for complete arc- and incandescent-lighting installations. The Brush licences, which were based in the main on the importing of electrical equipment from America, appear to have conferred an exclusive right to the use of the Lane-Fox patents for incandescent lamps, to which reference was made in the seventh article in this series.

Early in 1883 it became known that St. George Lane-Fox had compromised himself with a rival firm known as the British Electric Lamp Co., with whom he had formerly been associated. Finding that the directors of this company were averse to developing his ideas, he managed to recover his patents on payment of a substantial indemnity. He agreed, however, to allow the lamp company to continue to use his methods, provided that his name was not used on the product.

The impact of this disclosure was almost catastrophic. The general financial attitude towards electric lighting in the early eighties was distinctly one of speculation, and the paid-up capital of the two largest companies, Anglo-American Brush and Hammond, was £245000 and nearly £300000, respectively, in 1883–84. Money was readily subscribed by investors, and high prices had been paid to the Hammond parent company by their subsidiaries for licences. The Hammond company were compelled to indemnify their associates and looked in turn to Brush to reimburse them.

There were other difficulties—Brush could not meet their obligations in respect of deliveries, and equipment which arrived from the United States in 1883 was alleged by Hammond to have been so poorly constructed as to be unsaleable.

Furthermore, the American Brush company could not at this period supply self-regulating dynamos to meet the requirements of the new incandescent lamps for which they had contracted, and in these circumstances a legal action for damages was commenced by Hammond.

Meanwhile, to solve the problem of obtaining plant to meet the requirements of his licencees, Robert Hammond, towards the end of 1882, purchased for £36000 a controlling interest in the young firm of Ferranti, Thompson and Ince, an arrangement which lasted until the Hammond parent company was forced by a trade recession into voluntary liquidation in 1885–86.

Some idea of the breadth of vision displayed by Robert Hammond may be gained from the following excerpt from an address to his shareholders in 1882:

> The electric light has got such a strong hold upon the public that one is apt to forget that there is anything else that can be done with electricity. There is also the question of power. In many places throughout England there are various mills and so on which are compelled to waste a considerable amount of power. There are mills which generate an immense amount of heat, and this heat, if properly utilised, could be converted into power, and into force, which could drive machinery not only at the mill, but drive machinery at a distance. Thus there is ample scope for the electrical engineers to work out the most lucrative business in the direction of utilising this waste power.

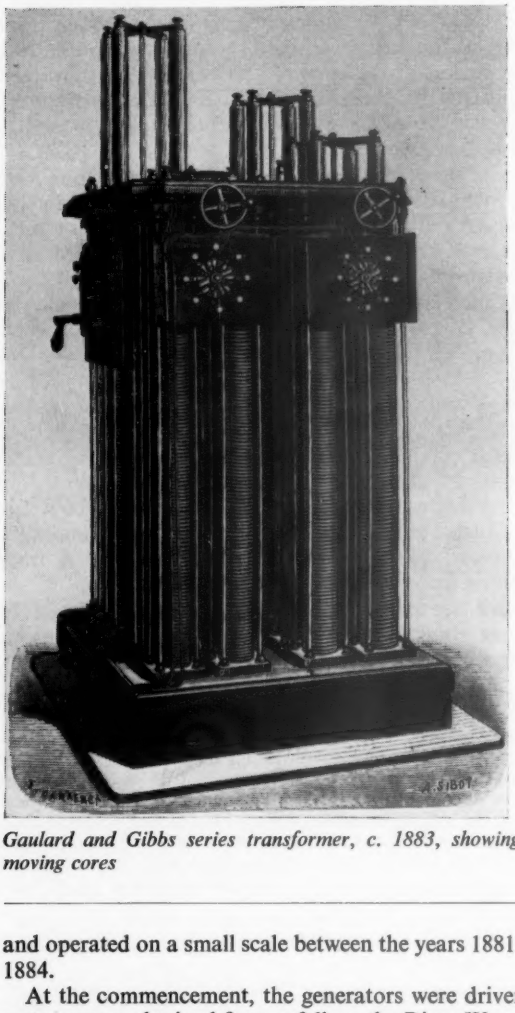
Early Stations

The Holborn Viaduct generating station in London, which commenced operation in January 1882, was probably the first electrical power station in the world to cater for the needs of the private consumer, although, as we have shown, d.c. central stations for the exclusive purpose of supplying street lighting had been in use in America since 1879.

The Holborn Viaduct scheme was financed by the

Edison company and operated at 110 volts d.c. It comprised, at first, a single Edison dynamo directly driven from a horizontal steam engine at a speed of 350 r.p.m. The dynamo was rated to supply up to a thousand 16-candle-power lamps, equivalent to a maximum load of approximately 60 kW.

A similar small generating station was established about the same time at Godalming in Surrey. It was launched in 1881 by an announcement that the Town Council had accepted a tender from Calder and Barret to light the streets. The project was sponsored by another manufacturing company, Siemens Brothers of Woolwich,



Gaulard and Gibbs series transformer, c. 1883, showing the moving cores

and operated on a small scale between the years 1881 and 1884.

At the commencement, the generators were driven by water power obtained from a fall on the River Wey, and the station thus became one of the earliest hydro-electric ventures. The water turbine was abandoned, however, in 1882 in favour of a steam engine, owing to the unreliable flow of water in the river.

The Brighton project originated in a display of a Brush arc-lighting installation given by Hammond in the town in December 1881. Both the Brighton and Eastbourne stations were commissioned about the same time, that is early in 1882, initially with d.c. generators, which were later replaced by alternators. Speaking at a meeting of The Institution in 1888, Robert Hammond inferred that both stations had been running for some years in this way, and it is probable that the a.c. machines were installed during 1884.

It is stated that in Brighton the 2·4 kV cables were carried overhead, whereas in Eastbourne 2 kV mains were laid underground. By 1888 both towns possessed between seven and eight miles of mains and supplied from 2000 to 2500 incandescent lamps, together with arc lights, on a mixed circuit.

The Brighton undertaking was in the charge of Arthur Wright (1858–1931), the inventor of a most successful electrolytic meter. Eastbourne was under the direction of H. M. Sayers (1860–1949) until 1885, when he was succeeded by H. W. Kolle (1864–1943). Both undertakings were owned with others by the Hammond company, whose Chief Engineer, W. Lowrie, in association with H. W. Kolle and C. J. Hall (1862–1915), was responsible for the design of the transformers which operated on what has been referred to as the Lowrie-Hall system.

Gaulard and Gibbs 'Transformer'

Perhaps the most famous central generating station of this early period was that erected by Sir Coutts Lindsay and his associates at the Grosvenor Gallery, New Bond Street, London, the primary object being to provide arc lighting for the Gallery. The station was at first equipped with two Siemens high-voltage alternators and supplied its consumers through Gaulard and Gibbs series 'transformers', which had recently been introduced. The 'transformers' were, in fact, voltage regulators and were sometimes made with moving cores of soft iron and later with fixed cores and a moving cylinder placed between them.

As is well known, the transformer operates in accordance with the principle of mutual inductance between two windings, which was discovered by Faraday in 1832. It is equally well known that Faraday was not interested in commercial exploitation and was content to leave to others the development of his researches. The first practical application of the new principle was that of the Ruhmkorff coil, better known as the induction coil, by means of which high-voltage phenomena could be demonstrated.

Various experimenters such as Jablochkoff, Fuller, the Sawyer–Man company and others had endeavoured to adapt the induction coil to electrical transmission, but without success. Lucien Gaulard and John Dixon Gibbs carried out similar experiments around 1882 and were successful in demonstrating a high-voltage alternating-current system with a single air-cored step-down transformer at the Westminster Aquarium in April 1883. At

Dr. John Hopkinson, F.R.S. (1849–98)

this demonstration the primary windings of two transformers were connected in series and fed from a high-voltage alternator. The secondary windings were independent, and those on one transformer supplied a single 40 amp load comprising 26 carbon-filament lamps. Three separate secondary windings on the other transformer supplied, respectively, five carbon-filament lamps, a Jablochkoff candle type of arc lamp, and an electric motor of a type unspecified. Gaulard and Gibbs's apparatus was covered by British Patents 4362 of 1882 and 1020 of 1883. The first application of the system was in England, where it was used to supply lighting at the Notting Hill Gate, Edgware Road, King's Cross and Aldgate Stations of the Metropolitan Railway. The system was supplied at high voltage (probably about 2kV) from generating plant at Edgware Road Station and was fed on a series circuit. The transformers were sometimes known as secondary generators, and the method of using them in practice appears to have been to load the secondaries with a reactance, which was referred to by J. H. Gordon, an early pioneer, as a 'choking coil'—a term which proved both appropriate and lasting. In the contemporary electrical Press the new system was treated with a considerable amount of reserve, in spite of the publication of a favourable report by Dr. John Hopkinson. The apparatus was shown at the principal exhibitions in England and on the Continent and undoubtedly provoked considerable discussion among the leading contemporary electrical engineers.

Priority of Claim

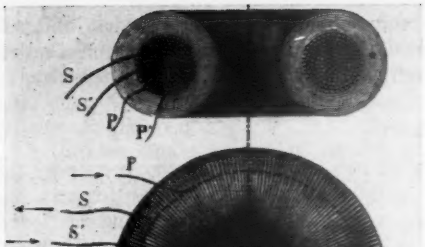
The honour of being the first pioneer to propose the conventional parallel connection of transformers has been claimed for Ferranti in England, and Déri and Zipernowsky in Hungary. The claim for Ferranti is based upon the fact that, soon after the Grosvenor Gallery station was opened in 1884, the shortcomings of the series system became apparent and Ferranti was consulted.

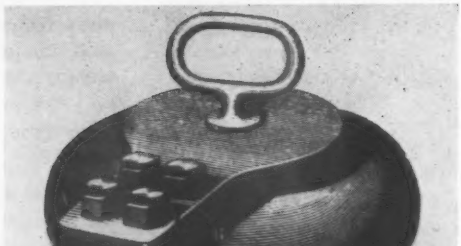
In 1886 he was appointed Chief Engineer and requested to introduce remedial measures. This he did by replacing the Siemens alternators and Gaulard and Gibbs series transformers by others of his own manufacture. The construction of the new step-down transformers was in

Dr. Sebastian Ziani de Ferranti, F.R.S. (1864–1930)

accordance with his patent of 1885, and the primary windings were connected in parallel on a ring main. The claims of Déri and Zipernowsky appear to arise out of improvements which these pioneers introduced as a result of making similar observations on the Gaulard and Gibbs series system, when shown at the Turin Exhibition of 1884. Their British patents also date from 1885.

Notwithstanding all these facts, priority may be claimed for Rankin Kennedy, later well known as a





Transformers of Bláthy, Déri and Zipernowski, made by Ganz and Co. of Budapest, 1885

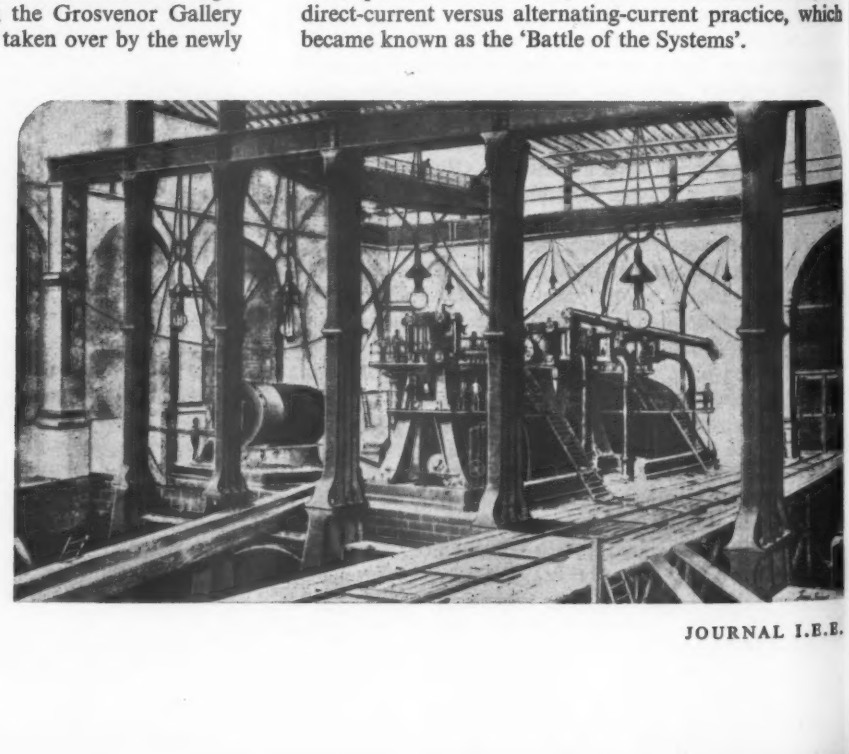
consulting engineer in Scotland, who, in a letter to the *Electrical Review* published on the 9th June 1883, described his experiments with the series system which he considered to be impracticable, and went on to say:

> In parallel arc, however, the secondary generator is a beautifully self-governing system of distribution; but what about the size of conductors for such a system? Prodigious!

It has been stated that, on the advice of Kelvin, Kennedy did not patent the arrangement he had evolved. This, if true, is strange advice from a man who throughout his life had patented ideas as they occurred to him, irrespective of whether he had any immediate application in view, and subsequently reaped a rich reward in royalties as the electrical industry developed.

The last had not been heard of Gaulard and Gibbs, however. As soon as the action taken by Ferranti became known, the two inventors demanded damages and a substantial royalty from the Grosvenor Gallery Co., which in August 1887 was taken over by the newly formed London Electric Supply Corporation. By this time Gaulard and Gibbs were threatening an injunction against the new company, and on legal advice Ferranti petitioned the High Court for the revocation of the patent granted to them on the ground of lack of originality, an action which—fortunately for Ferranti—proved successful.

The primary object of the London Electric Supply Corporation was to raise capital for a new project, which centred on the establishment at Deptford of a vast power station to supply a large part of London. The new station was to generate in units of 10000h.p. and to transmit alternating current at 10kV. It was some years before Deptford was in a position to supply power to its consumers, and meanwhile the project was discussed among engineers in so fervent a manner as to develop into a discussion, sometimes acrimonious, of direct-current versus alternating-current practice, which became known as the 'Battle of the Systems'.



A view of Deptford power station, London, during its construction in 1889

Wiring Regulations—Recent Interpretations

(Issued on the 28th April 1958)

THE 13th Edition of the Regulations for the Electrical Equipment of Buildings was issued on the 1st September 1955. The following abstracts of interpretations, the fifth group to be published,* are of general interest and involve clear-cut issues. As is customary, the names of inquirers are not included. In some instances the inquiries and replies have been edited to make the interpretations of more general application. In view of the interest widely expressed, arrangements have been made to release further abstracts of this kind at intervals depending on the number of inquiries of general interest received, but not more frequently than once in three months.

It should be borne in mind that The Institution cannot undertake to comment on particular installations or types of equipment and material. Such a duty falls within the province of a professional consulting engineer or a testing establishment. Nor does The Institution attempt to adjudicate on differences of opinion which may arise between supply undertakings and consumers: the statutory provisions for dealing with such matters in Great Britain† are contained in the Electricity Supply Regulations, 1937† (H.M. Stationery Office), and in Northern Ireland in the Regulations of the Ministry of Commerce.

Inquiry 42 *Regulation* **101** *and Table* **2**

For the control of a three-phase, four-wire supply, the Regulations require that only the phase conductors be controlled by the main switch or circuit-breaker; thus, the neutral may be isolated by a removable link. Is this arrangement permissible also for a single-phase supply, i.e. may the phase conductor only be controlled by the main switch and may the neutral be connected by a link?

Reply

Regulation 101 and Table 2, which relate only to main switchgear for the control of a complete consumer's installation, clearly require the use of a double-pole main switch for all 2-wire systems of supply. Throughout the remainder of a consumer's installation, the requirements of Regulations 2, 107, 314 and 317 should be observed.

* Reprints of the following earlier sets of abstracts remain available, price 6d. each post free:

Interpretations	*Date of Issue*	*Publication Reference*	*Regulations Nos.*
1. 1–22	3.9.56	*Journal I.E.E.*, 1956, 2, October, p. 598	108, 112(B), 114(B), 115, 203, 204(B), 206(A), 207(G), 209(F), 229(B), 307(A), 314, 315, 316, 401, 403, 404, 405(B), 603(A), Section 8. Tables: C, 1, 7, 16–22.
2. 23–27	3.12.56	*Journal I.E.E.*, 1957, 3, January, p. 31	114(B)(ii), 214(B), 322, 403, 404 405(D).
3. 28–31	1.3.57	*Journal I.E.E.*, 1957, 3, March, p. 154	407(iv), 503. Tables: 12–24, 26.
32–41	2.9.57	*Journal I.E.E.*, 1957, 3, September, p. 496	General, 110, 115, 208(D), 218, 229, 311, 314, 315, 404, 405(C), 606(i).

† By virtue of Section 60 of the Electricity Act, 1947, and Section 1 of the Electricity Re-organization (Scotland) Act, 1954, these Regulations made by the Electricity Commission now have effect as if made by the Minister of Power and the Secretary of State for Scotland acting jointly under these Acts.

Inquiry 43 *Regulations* **101, 102, 105** *and Tables* **A** *and* **2**

It would appear from Regulation 102 and Table A that an earth-leakage circuit-breaker with overload features may be the first component of the consumer's installation on the load side of the consumer's terminals but that an earth-leakage circuit-breaker without overload features must be preceded by consumer's main fuses and consumer's linked switch.

Subject to certain prescribed conditions, however, Regulation 105 permits the omission of consumer's main fuses and Note 2 to Regulation 102 permits the service fuses to be the means of isolation. If these prescribed conditions do obtain [it being assumed that the earth-leakage circuit-breaker may be considered to be the main switch referred to in Regulation 105(ii)] and the requirements of Column 2, Table 2, are fulfilled, is it in order to employ an earth-leakage circuit-breaker without overload features as the first component on the load side of the consumer's terminals?

Reply

Basic requirements for main switchgear are indicated in Regulation 101 (with Table 2) and Regulation 102(A), while Regulation 102(B) (with Table A) indicates the general sequence.

Where Regulation 105 is applicable, consumer's main fuse(s) may be omitted subject to the provisos indicated, and this practice is supported by Note 2 to Regulation 102(A)(iii). With regard to agreement by the supply undertaking, attention is drawn to the notice circulated to the technical Press on the 2nd August 1956.*

A linked earth-leakage circuit-breaker complying with B.S. 842, which has an operating handle, can take the place of the consumer's main switch, provided:

(*a*) it is arranged for ready operation (see Regulation 7),
(*b*) it breaks the number of poles required by Table 2 on page 96.

The relaxations indicated in the last two paragraphs are admissible only provided the current rating of the earth-leakage circuit-breaker and of the cable between the meter terminals and the consumer's circuit fuses is not less than the rating of the service fuse, in accordance with Regulation 108, subject to the application, where appropriate, of exemption (vii).

With these limitations, the arrangement described is thus admissible provided the supply undertaking agree.

* The Press notice referred to read as follows:
'Regulation 105 of the 13th Edition of the Regulations for the Electrical Equipment of Buildings states:

'"The consumer's main fuse(s) or circuit-breaker may be omitted provided
(i) the supply undertaking so agrees,
and (ii) sub-circuit fuse(s) or circuit-breaker(s) providing any necessary further electrical protection are within reach from the main switch."

'The Secretary of The Institution has been informed by the Central Electricity Authority on behalf of the Area Boards, and by the South of Scotland Electricity Board and the North of Scotland Hydro-Electric Board, that they are prepared to consider sympathetically applications from consumers, or contractors acting on their behalf, to follow the practice authorized in Regulation 105. Furthermore, where installations include a consumer's supply-control unit complying with B.S. 1454: "Consumers' Electricity Control Units", individual applications for authorization need not be made, the foregoing bodies having stated that in the circumstances their agreement to the practice may be assumed.'

Additional recommendations for good practice are made in Code 322.103 'Installation of Consumers' Electricity Supply Controls for Small Dwellings (for A.C. Systems)'.

Inquiry 44 *Regulation* **104**

It has been suggested that Regulation 104 precludes the use of a double-pole linked switch for isolating a single-phase circuit from the supply, unless the neutral pole makes first and breaks last. Such an arrangement of the neutral pole is usual for three-phase-and-neutral circuits, and it is appreciated that this is necessary to prevent possible danger due to voltage rise on an unbalanced circuit at the moment of break.

For single-phase circuits, however, no voltage rise can occur even if the neutral breaks momentarily before the line, and we should be glad to know whether switches for such circuits having simultaneous break on line and neutral are regarded as complying with the Regulation.

Reply

It is confirmed that a double-pole linked switch with simultaneous break of live and neutral conductors meets the requirements of Regulation 104, for the isolation of the conductors of a single-phase supply.

Inquiry 45 *Regulation* **114(B)**

During the currency of the 12th Edition, it was ruled that it was permissible to wire a spur directly from the terminals of the 30amp fuse protecting a ring circuit.

Clause 2 of Regulation 114(B) of the 13th Edition of the Regulations states, however, that 'spurs shall be connected to a ring circuit in socket-outlets, or in suitable joint- or junction-boxes'. In view of this we shall be pleased if you will now let us know whether it is intended that spurs shall not be wired from the ring-circuit fuses but only connected to the circuit cable at some outlying point.

Reply

For the purposes of Regulation 114(B)(ii) fusegear may be regarded as constituting a 'joint box' (see definition on page 12, viz.: 'a box forming part of a wiring installation, provided to contain joints in the conductors of the cables of the installation'). There is thus no objection to a spur of a ring circuit being connected at the terminals of the fuse protecting the ring, provided that the terminals are capable of anchoring the number of conductors concerned in accordance with Regulation 207. Attention is directed to the Note to Regulation 114(B)(i) regarding the bunching of cables.

International Convention on Microwave Valves

A LIST is given below of the papers and contributions presented at the International Convention on Microwave Valves, which was held in the Institution building during the week 19th to 23rd May. The main headings refer to the sessions at which the material was presented. The complete proceedings of the convention, comprising the papers, contributions and discussions, will be published as Supplements to Part B of the *Proceedings* of The Institution, and an announcement about this will be made later. Individual reprints of papers will not be available. Entries marked with an asterisk are contributions.

OPENING SESSION

Introductory Lecture
R. COCKBURN, C.B., O.B.E., M.SC., PH.D.

TRAVELLING-WAVE TUBES I

***Design of a 100 mW Helix Travelling-Wave Amplifier at 50 Gc/s**
W. E. DANIELSON, H. L. MCDOWELL *and* E. B. REED

***Experimental Medium-Power High-Gain Travelling-Wave Tubes of Very Short Structure with Permanent-Magnet Focusing for the 4 and 6 Gc/s Bands**
W. KLEIN *and* H. NEUFISCHER

An Application of the Spatial-Harmonic Wave on a Large-Diameter Helix
J. KOYAMA

MAGNETRONS

***Symmetric Tuning of Magnetrons by means of a Cavity**
C. H. AZEMA

A New Design of High-Power S-Band Magnetron
H. A. H. BOOT, B.SC., PH.D., H. FOSTER *and* S. A. SELF, B.SC.

The Theory of Circular Magnetrons with Uniformly Rotating Space Charge
R. DUNSMUIR, B.SC., M.SC., PH.D.

A 3·8 mm-Wavelength Pulsed Magnetron
A. J. MONK, B.SC.

***An Investigation into the Factors Affecting the Life of Magnetrons**
F. C. THOMPSON, PH.D.

***A 200 kW 80-Watt Magnetron**
R. ZWOBADA

TRAVELLING-WAVE TUBES II

***Theory of Travelling-Wave Tubes using Paralleled Electron Streams**
C. K. BIRDSALL

***Some Transient Phenomena in Microwave Tubes**
A. V. BROWN, B.A., PH.D.

A 4 Gc/s Travelling-Wave Tube for Microwave Radio Links
P. F. C. BURKE

Power Limitations in Helix Travelling-Wave Tubes and the Application of Fluid Cooling
G. M. CLARKE, PH.D., B.A.

*An M-Type Pulsed Amplifier
O. DOEHLER, A. DUBOIS *and* D. MAILLART

A Package-Type Travelling-Wave Amplifier with a New Magnetic Focusing System
M. KENMOKU *and* S. YASUDA

A 20 kW Pulsed Travelling-Wave Tube
J. D. PEARSON, M.SC., *and* H. S. COCKCROFT, B.SC.

*Constructional and Design Difficulties of High-Power Travelling-Wave Tubes in the 10 Gc/s Region
R. G. ROBERTSHAW *and* C. H. DIX, B.SC.

GAS-DISCHARGE VALVES AND PLASMA

*Measurement of Clean-Up in Gas-Discharge Tubes using Radioactive Krypton
D. W. DOWNTON

A New Type of Water-Vapour Replenisher and its application to a T.R. Switch
T. L. DUTT, B.SC., *and* W. I. MOORE

Electro-Mechanical Modes in Plasma Waveguides
R. W. GOULD *and* A. W. TRIVELPIECE

*A Wide-Band Multi-Way Electronic Switch
S. M. HAMBERGER

Active Microwave Duplexing Systems
P. O. HAWKINS

*One-Dimensional Non-Stationary Electrostatic Flow in a Plasma
G. KALMAN

Passive Protection Cells
P. D. LOMER, M.SC.

A Microwave Pulsed Attenuator using an R.F.-Excited Discharge
P. D. LOMER, M.SC., *and* R. M. O'BRIEN

A New Form of X-Band Pre-T.R. Cell
A. B. PARKER, B.SC., PH.D.

BACKWARD-WAVE OSCILLATORS I (DEVICES)

*Frequency Pushing in Crossed-Field Oscillators: A Comparison between the C.W. Magnetron and the Magnetron-Type Backward-Wave Oscillator
R. I. BUICK, A. REDDISH *and* I. J. ZUCKER

*Operation Characteristics of the 'Carmatron' Tube
O. DOEHLER, B. EPSZTEIN *and* J. ARNAUD

*Results obtained on Crossed-Field Carcinotrons under Pulsed Operation
M. FAVRE

*Anomalous Behaviour in the 'M' Carcinotron
J. NALOT *and* R. VISOCEKAS

GRID CONTROL VALVES

Electrode Spacing in Disc-Seal Triodes
PROFESSOR M. R. GAVIN, M.B.E., M.A., D.SC., W. FULOP, PH.D., *and* L. J. HERBST, PH.D.

Microwave Triodes
H. GROENDIJK

*Advances in Very-High-Power Grid-Controlled Tubes, Techniques and Applications
M. V. HOOVER

Magnetic Coupling by Parallel-Wire Grids and Soldered Cross-Lateral Grids in Disc-Seal Triodes
J. KELLERER

A New Method of Measuring the Input Admittance of Ultra-High-Frequency Triodes
T. TAKASHIMA *and* T. MISUGI

Measurement of the Active Admittances of a Triode at 4 Gc/s
M. T. VLAARDINGERBROEK

A New Method of making Accurate Fine-Wire Grids for use in Radio Valves
A. E. WIDDOWSON, B.SC., PH.D., A.INST.P., D. C. GORE, B.SC.(ENG.), *and* C. H. BUTCHER

BACKWARD-WAVE OSCILLATORS II (THEORY)

The Magnitude of the Locking Signals for Backward-Wave Oscillators
E. A. ASH, PH.D.

*Interaction of Electromagnetic Waves and Electron Beams in Systems with Centrifugal Electrostatic Focusing
Z. S. CHERNOV

*An Experimental Study of Large-Signal Behaviour in M-Type Tubes in the Presence of Space Charge by the use of an Analogue
B. EPSZTEIN

*A New Crossed-Field Travelling-Wave Tube, the M-J Tube
C. C. JOHNSON *and* C. K. BIRDSALL

*Aspects of M-Type Interaction with emphasis on the Backward-Wave Magnetron Amplifier
J. W. KLÜVER

TECHNOLOGY

*High-Power Waveguide Window
D. CHURCHILL *and* T. D. SEGE

A New Ceramic Waveguide Window for use on X-Band Valves
W. F. GIBBONS, M.A., *and* A. V. WHALE, B.SC.

*Study of the Lives of Dispenser-Type Barium-Tungsten Cathodes
T. HASHIMOTO

*Photo-Etching Molybdenum Foil
H. A. C. HOGG

High-Power Windows at Microwave Frequencies
J. V. LEBACQZ, J. JASBERG, H. J. SHAW *and* S. SONKIN

*Application of the Spark-Machining Method to Millimetre-Wave Magnetrons
M. NISHIMAKI *and* T. ASABA

*A New Kind of Heater for Rugged Indirectly Heated Cathodes
J. R. PICKIN *and* A. J. WOODWARD

SPACE-CHARGE WAVES

Space-Charge Waves on Annular Beams in Drift Tubes
A. H. W. BECK, B.SC.(ENG.), *and* P. E. DEERING

Microwave Amplification using an Unstable Electron Beam in Crossed Electric and Magnetic Fields
D. J. HARRIS, B.SC., PH.D.

***Magnetic Oscillations in Electron Beams**
R. H. C. NEWTON

***A Variation Principle for Small-Amplitude Disturbances of Electron Beams**
P. A. STURROCK

***Large-Signal Theory of Linear-Beam Tubes**
C. C. WANG

SEMI-CONDUCTORS AND NEW METHODS OF GENERATION

***Parametric Amplification of Space-Charge Waves**
A. ASHKIN, T. J. BRIDGES, W. H. LOUSELL *and* C. F. QUATE

Theory of the Microwave Crystal Mixer
C. BARON, M.SC.

Some Proposals for Generating High-Frequency Electromagnetic Waves using the Doppler Effect
R. B. R-S-HARVIE, B.A.

***Operation of Intrinsic Negative-Resistance Tubes in Different Types of Amplifiers**
F. HÜLSTER

Fast-Wave Interactions with an Electron Film at Cyclotron Resonance
A. KARP

***Intrinsic Negative-Resistance Tubes as Hyperfrequency Amplifiers**
E. ROSTAS

***Junction Diodes in Microwave Circuits**
A. UHLIR

ATOMIC AND MOLECULAR GENERATORS I

Introductory Talk
K. W. H. STEVENS, M.A., D.PHIL.

***A Parametric Amplifier using Lower-Frequency Pumping**
K. K. N. CHANG *and* S. BLOOM

***A Two-Level Solid-State Maser**
J. P. GORDON

***Microwave Parametric Amplifiers and Convertors**
G. WADE *and* H. HEFFNER

ATOMIC AND MOLECULAR GENERATORS II

***Construction of a Mobile Caesium-Frequency Standard**
A. H. W. BECK, B.SC.(ENG.), *and* J. LYTTOLLIS, M.A.

Theory of Three-Level Paramagnetic Masers. (i) Quantum Theory. (ii) Amplification and Oscillation. (iii) Output Noise Power Spectrum. (iv) Noise Figure
P. N. BUTCHER, PH.D.

***Travelling-Wave Solid-State Masers**
A. E. SIEGMAN, P. N. BUTCHER, PH.D., J. C. CROMACK *and* W. S. C. CHANG

RESONATORS AND SLOW-WAVE STRUCTURES

A New Type of Slow-Wave Structure for Millimetre Wavelengths
E. A. ASH, PH.D.

Modified Transmission-Line Couplers for Helices
E. A. ASH, PH.D., *and* J. D. PATTENDEN

Some Aspects of the Design of a Helical Coupler for a Travelling-Wave Tube Operating in the 2 Gc/s Band
P. A. LINDSAY, PH.D., *and* K. D. COLLINS

The Coupling of Three Coaxial Helices
B. MINAKOVIC, B.SC.(ENG.)

***Results on Delay Lines for High-Power Travelling-Wave Tubes**
P. PALLEUL *and* J. ARNAUD

A Structure, using Resonant Coupling Elements, suitable for a High-Power Travelling-Wave Tube
A. F. PEARCE, PH.D.

***Theoretical Investigation of Some Delay Structures for High-Power Travelling-Wave Tubes**
F. SELLBERG

***Dispersion Curves for a Helix in a Glass Tube**
D. T. SWIFT-HOOK

***Dielectric Loading for U.H.F. Valves**
G. B. WALKER, M.A., PH.D.

***Multiple Ladder Circuits for Millimetre-Wavelength Tubes**
R. M. WHITE, C. K. BIRDSALL *and* R. W. GROW

NOISE

***Progress in Low-Noise Microwave Tube Design**
W. R. BEAM

Frequency Noise in Travelling-Wave Tubes
R. LIEBSCHER *and* R. MÜLLER

***Calculations Concerning the Noisiness of a Drifting Stream of Electrons**
J. R. PIERCE

***Noise in Backward-Wave Oscillators**
N. W. W. SMITH

***Oxide Cathodes for Low-Noise Travelling-Wave Tube**
E. WINDSOR

VELOCITY-MODULATION VALVES I

Long-Transit-Time Multipactoring at Ultra-High Frequencies, and the Effect of Surface Emitting Layers
D. K. AITKEN

***An Experimental Wide-Band Klystron Amplifier**
W. L. BEAVER

A Three-Cavity L-Band Pulsed Klystron Amplifier
A. H. W. BECK, B.SC.(ENG.), *and* P. E. DEERING

The Choice of Beam and Coupling Parameters for Broad-Band Klystrons
M. O. BRYANT, B.SC., PH.D.

An Experimental Investigation of Velocity-Modulated Electron Beams
PROFESSOR A. L. CULLEN, PH.D., B.SC., *and* I. M. STEPHENSON, PH.D., M.SC., B.SC.

Factors Influencing the Design of Multi-Cavity Klystrons
H. J. CURNOW, B.SC.

***Phase Relationships in a Stagger-Tuned Klystron Amplifier**
N. E. DIXON

A 5% Bandwidth 2·5 MW S-Band Klystron
P. G. R. KING, B.SC.

***Studies in the Development of High-Power Klystrons**
K. H. KREUCHEN, D.PHIL., F.INST.P., *and* N. J. DISERENS, B.SC.

A Theoretical and Experimental Study of a High-Power 400 Mc/s Klystron
R. LATHAM, E. D. DRACOTT, M. FLINN, D. A. GRAY, G. NASSIBIAN, J. C. VOKES *and* G. WEXLER

MEASUREMENTS

***Measuring Modulation Noise from a High-Power C.W. Klystron Amplifier**
D. E. T. F. ASHBY *and* R. B. DYOTT

***Technology of Carcinotrons for Short and Long Wavelengths**
G. BOUCHER *and* W. SABOTKA

***Analysis of Thin, High-Current-Density Electron Beams by means of a Mechanical Scanner**
T. FUJII *and* S. SABURI

The Coaxial-Line Diode: a Rectifier of Microwaves
P. O. HAWKINS, H. J. CURNOW, B.SC., *and* R. REDSTONE

***Electron-Beam Techniques for Measuring Circuit Velocity and Impedance**
H. R. JOHNSON *and* R. R. BAGI

Measurements of Field Patterns for a Comb-Type Slow-Wave Structure
K. KAMIRYO, H. HOZUMI, Y. SHIBATA *and* Y. FUKUSHIMA

***Measuring Techniques for M-Type S- and X-Band Backward-Wave Power Oscillator**
D. D. SILVESTER

ELECTRON OPTICS I

The Electron-Optics of High-Current-Density Electrostatic Electron Guns
M. R. BARBER, B.E., B.SC., *and* K. F. SANDER, PH.D.

***Electron-Beam Tracing in Electric and Magnetic Fields taking into account Space Charge**
J. R. HECHTEL *and* K. R. JOHNE

***Klystrons without Magnetic Beam Focusing**
O. HEIL

Non-Laminar Electron Beams in High Magnetic Fields
T. W. JOHNSTON

***The Application of Electron-Beam-Tracing Methods to the Study of High-Perveance Guns**
M. PICQUENDAR

The Design and Performance of High-Current-Density Electron Guns
P. C. RUGGLES, B.SC.

The Effect of Anode Aperture on a Dense Beam
G. A. STUART, B.A., *and* B. MELTZER, B.SC., PH.D.

A Simple Method for Calculation of Electron-Beam Contours
W. VEITH

High-Density Electron Gun with Magnetic Field
C. ZLOTYKAMIN

VELOCITY-MODULATION VALVES II

Frequency Synchronization of an X-Band Reflex Klystron
C. S. AITCHISON, B.SC.

***The Tuning of Coupled-Cavity Reflex Klystrons**
P. E. V. ALLIN, B.A.

An Investigation into the Design of a Gridless Low-Voltage Reflex Klystron
R. C. BANNERMAN, B.SC., PH.D., J. A. LUCKEN, M.SC., F.INST.P., *and* D. J. WOOTTON, B.SC.

The Periodically-Loaded Travelling-Wave Multiple-Beam Klystron
V. A. HEATHCOTE, M.SC., P. A. LINDSAY, PH.D., J. BARRACLOUGH, B.SC., *and* J. R. NEWBY, B.SC., M.SC.

***Constant Reflector Voltage Klystron**
M. KENMOKU

The Effect of Reactive Loads on the Frequency-Modulation Characteristics of Reflex Klystrons
B. J. MAYO, M.SC., A.INST.P.

A New Analysis of Electronic-Hysteresis and Secondary-Emission Phenomena in Local-Oscillator Reflex Klystrons
M. R. MUSSON-GENON *and* M. C. AUDOUIN

A New Development of the Monotron Oscillator
J. R. PICKIN *and* D. H. TREVENA

An Experimental Annular Reflex Klystron
D. J. WOOTTON, B.SC., J. A. LUCKEN, M.SC., F.INST.P., *and* R. C. BANNERMAN, B.SC., PH.D.

ELECTRON OPTICS II (CROSSED FIELD)

***Periodic Electrostatic Focusing**
H. A. C. HOGG

***Some New Solutions to the Equations of Space-Charge Flow**
P. T. KIRSTEIN *and* G. S. KINO

***Theoretical Study of Electron Guns of M-Type Travelling-Wave Tubes**
A. LEBLOND

***A Method of Focusing Electron Beams**
B. T. MURPHY

***An Electron-Trajectory Calculator and its Component Poisson Cell**
J. E. ROWE *and* M. J. MARTIN

***Production and Focusing of High-Density Sheet Beams**
P. A. STURROCK

***Electrostatic Focusing of Electron Sheet Beams**
W. E. WATERS

THIRD EUSEC CONFERENCE ON EDUCATION AND TRAINING

The Third Conference of Representatives from the Engineering Societies of Western Europe and the United States on Engineering Education and Training was held in Paris from the 16th to 20th September last year. The Proceedings of the Conference have now been published, and an announcement about this appeared in the May Journal, p. 280.

Introduction

At the Eusec Conference held at The Hague in 1951 it was agreed that an exploratory conference should be held on the subject of 'The Education and Training of Professional Engineers'. As a result, a conference was held in London in 1953 at the invitation of The Institutions of Civil, Mechanical and Electrical Engineers and is known as the 'First Conference'. A Second Conference was held in Zurich in 1954.

One session of the Second Conference discussed education at engineering schools of university level, but not much detailed information was available to delegates. The Conference recommended that an executive committee should be formed to collect particulars of engineering schools at university level and to organize a Third Conference for studying the subject.

The Executive Committee decided that six subjects, including aspects of general and engineering education, practical training, professional status, and a glossary of engineering education terms, should be studied in detail. They appointed a general rapporteur for each subject, who would send to every participating country a comprehensive questionnaire on his subject and prepare a report from the replies received. These reports were presented at a Third Conference held in Paris in September 1957.

Glossary and Block and Flow Diagrams

Reporter: Dr. A. W. J. Mayer (Netherlands)

Delegates agreed that engineering education should be divided into three categories: first level (elementary); second level (secondary); and third level (higher or university). This could be done only very roughly since there are so many fine distinctions within each level between and within nations. Block diagrams show the steps and their interlocking by which education within each country progresses from first level to third level. The glossary will be a valuable guide to those studying the educational systems of other countries.

General Education before Admission to Engineering Schools of University Level

Reporter: Dr. Willis Jackson (United Kingdom)

Owing to the different examination methods, delegates found it difficult to make any comparison of the standards in mathematics, chemistry and physics. There are wide discrepancies between times allocated to science subjects, from about 70% in France and the United Kingdom to about 23% in Finland. The high failure rate in the first year of engineering courses (up to 30%) seems common in many countries. The types of school-leaving examination differ widely and include: (*a*) partly oral in most Continental countries; (*b*) written papers in the United Kingdom (showing the mental processes involved); and (*c*) the correct selection from a number of alternative answers in the United States.

Engineering Education at University Level

Reporter: Dr. Willis Jackson (United Kingdom)

Delegates had insufficient information about syllabuses and examinations to compare countries quantitatively.

Generally, there is little difference in the curricula for the first two years in civil, mechanical or electrical engineering courses. In the third and subsequent years they become specialized, and on the Continent there may be further specialization in each branch. A proportion of the study time is devoted to non-technological subjects, e.g. economics and administration, but it is not clear how seriously these are taken (it depends on the lecturer), and students are not examined in them.

It was agreed that management should not be taught at university level, but some liberal subjects—especially history and economics—should be included. Delegates particularly noted the high failure rates, both in the first year and over the whole course, though not all those who fail are lost to the profession. In the Netherlands a failure rate of 50% was quoted. France was an outstanding exception, with a failure rate of only about 1%, mainly owing to the severe entrance examinations in mathematics. There was general agreement about the desirability of close association between teaching institutions and industry. On the Continent much use is made of teachers working in industry (in Holland, France and Switzerland over 50%); and most countries encourage full-time staff to undertake consulting work.

Practical Training

Reporter: Mr. H. G. Meyer (Switzerland)

Mr. Meyer's report disclosed differences of opinion whether practical training should be the subject of regulations, or should merely follow recommendations. In a certain number of American engineering schools, in the last terms of study, the student works alternately at the university and in industry. On the Continent no regulations exist to control practical training after the completion of engineering studies, but all representatives agreed that until a graduate had had practical experience he was not a fully competent engineer.

Post-First Degree Education

Reporter: Mr. O. Akerman (Sweden)

In this report, the term 'post-first degree' as distinct from 'post-graduate' had been adopted, because of a wide divergence in interpretation of this concept between the Scandinavian and Central European countries on the one hand, and Great Britain and the United States on the other. Considerable misunderstanding arose from the mistaken belief that in the United Kingdom the M.Sc. rather than the B.Sc. degree corresponds to the Continental-European first degree ('Ing') standard. Also, the need to distinguish between the levels of the United Kingdom and United States first degrees became evident during the discussion.

Delegates considered that in all branches of engineering, post-graduate courses were important, but they recognized the difficulty of fitting them into an industrial career. The Continental countries felt that the content of these courses should be recommended by the national engineering societies in consultation with industry.

Criteria for Professional Recognition

Reporter: Dean Thorndike Saville (U.S.A.)

Dean Saville's report disclosed that there was a wide variety of practice in according professional recognition to engineers. In some countries the designation 'engineer' is protected by law, and in some of these only graduates of designated colleges or universities may use certain specified titles comprising the term 'engineer', although anyone may legally practise engineering. In other countries membership of an engineering society is a prerequisite for recognition as a professional engineer. In the United States each State has a law governing the professional practice of engineering, applying mainly to engineers in private practice or in State or local government service but not to those in industry.

621.3:550.3 I.G.Y. PROGRESS REPORT

At this stage of the International Geophysical Year, which began in July 1957 and lasts for 18 months, it is apparent that this major exercise in international scientific collaboration will make important contributions to knowledge in the field of radio and telecommunication. This progress report, written by a special correspondent, discusses briefly the electrical engineering aspects of the results so far disclosed.

It is probably not an exaggeration to say that the ionospheric studies conducted during the I.G.Y.'s immediate predecessor, the Second Polar Year (1932–33) revolutionized understanding then of the ionized layers that reflect radio waves. It is already clear, halfway through the 18-month geophysical 'Year' that this international scientific effort will contribute quite as much of radical consequence to radio, telecommunication and the understanding of the medium through which radio waves travel above the earth's surface.

The I.G.Y. is organized on a scale that is at least an order of magnitude greater than that of the last Polar Year. It is not only that the I.G.Y. lasts half as long again, that the observations are distributed all over the earth and not limited to the polar caps, that more than 60 countries instead of a mere handful are contributing this time, and that the programme covers 13 disciplines instead of about half that number. Almost more significant than all these factors is that in any one of the disciplines represented in the Polar Year programme the volume of observations has been enormously increased and further amplified with the latest and most refined techniques—including of course even that of earth satellites.

Aurorae Occur Simultaneously

Britain can claim some of the first positive results. These relate to the application of a radar technique to the simultaneous study of the aurora in the northern and southern hemispheres by scientists of Manchester University. Paired equipments at Jodrell Bank, Cheshire, and Halley Bay, Antarctica, have shown that auroral displays occur at the same time in both hemispheres.

This had long been assumed to happen by workers in the field, but definite proof had not previously been possible. Through the use of identical radio probes able to register auroral disturbance at the extremities of the upper atmosphere by day as well as by night, summer and winter, at comparable geomagnetic latitudes in both hemispheres, the matter has been settled. These studies have also shown that aurorae approach nearer the equator in the northern hemisphere than in the south—as again had been supposed. Incidentally, the radio telescope at Halley Bay is the first ever to be operated in the Antarctic.

Ionospheric Discoveries

Do electric currents in the ionosphere flow in diffuse and complicated patterns, or do they in certain localities and at certain times concentrate into a 'neck' of current of many hundreds of thousands of amperes, encircling the globe in the upper atmosphere? The I.G.Y. has provided the opportunity to confirm findings made some years ago in South America that suggested that one such powerful current existed above the equatorial regions, associated in some way with the earth's rotation. Might not the magnetic effects observed at the earth's surface when magnetic storms occur be due to such a current or currents in the region of the E layer of the ionosphere?

A hypothesis put forward in 1940 by Chapman and Bartels in their work 'Geomagnetism' suggested that there were three such currents encircling the globe: one near each of the poles and one round the equator. They termed these currents *electro-jets*.

Preliminary findings from two sets of specially established geomagnetic stations on Pacific islands tentatively confirm the existence of the equatorial electrojet. The geomagnetic and geographic equators cross near the Line Islands in the Pacific. This area was therefore thought particularly suitable for a check on the electrojet from ground stations, since it would be expected that at such a location the current would be narrowed into a neck of limited horizontal dimensions with consequent increased current density and intensified activity at local noon. Three stations to give a species of triangulation and to fix the position and strength of the current in space were set up by United States personnel under the supervision of a British geophysicist from Imperial College and with the co-operation of the Cable and Wireless posts on the islands. Three more stations were established by the U.S. Coast and Geodetic Survey on islands in the Western Pacific. First results from both groups during magnetic disturbances since the stations were established last year confirm the existence of the equatorial electrojet, at an altitude of about 140 km, which tallies with its supposed location at about the E-layer level.

Rocket soundings in this area, being carried out from U.S. naval vessels, will give a more detailed picture of this current. The results are now awaited of similar rocket probes that have already been made in the Arctic and Antarctic, which may establish the presence or otherwise of the circumpolar currents also envisaged by Chapman and Bartels.

What precisely happens to the ionosphere during a radio blackout at periods of maximum sunspot activity such as that chosen for the I.G.Y.? While the blackout lasts, the pulses from vertical-incidence recorders—the standard means of checking the height and activity of the ionized layers—are not reflected as usual but are absorbed. It had long been thought, but not, until now

conclusively demonstrated, that this absorption must be caused by increased ionization in the lower atmosphere. On the 4th July 1957, while conditions were still much disturbed after the large solar flare of the 29th June, radio signals received from a rocket fired through the ionosphere showed an additional layer of ionization extending for about 12 miles below the normal lowest level of ionization. What is more, the rocket data on this occasion showed that the normal ion distribution throughout the ionosphere above the lowest, D, layer remained apparently undisturbed during the blackout. Subsequent rocket soundings have shown that the additional electron layer is caused by solar X-ray emission associated with the material thrown out at the time of a flare.

Another way of studying the effect of the sun on the ionosphere is to observe this region in 'no-sun' conditions—in other words, during the three months' polar night. Ionospheric observations throughout the polar night of 1957 produced the surprising result that, despite the prolonged absence of the sun, the ion concentration above the area remained very high. A diurnal variation continued to be apparent, although of course there was no alternation of day and night; this effect is at present being attributed to geomagnetic activity, though the relationship is not yet defined.

Explanation of Very-Low-Frequency Radio Noise

Researches associated with the Year are also substantially filling out the picture of what goes on above the F2 layer. New information from the study of 'whistler' atmospherics and other very-low-frequency radio noise suggests that ion density and molecular concentration at altitudes as great as two earth's radii may be sufficient to provide a path for radio waves guided along the flux-lines of the earth's magnetic field. 'Whistlers' originate with lightning flashes at the earth's surface but are picked up thousands of miles away, where the descending note of the signals suggests that the length of the path travelled has sorted the frequencies in time.

Study of other previously unexplained radio noise at very low frequencies—the so-called 'tweeks', 'hiss', and the 'dawn chorus'—has stimulated the hypothesis, put forward in recent months by the American worker, Roger Gallet, that solar particles arriving at the extremities of the earth's 'atmosphere' transfer energy to very-low-frequency radio waves there by means of the travelling-wave-tube principle.

Miniature tape-recorder used in Explorer III

Solar Cells

It may seem churlish to describe the I.G.Y.'s achievements so far without mentioning the advent of the earth satellites. One must admit, however, that the first five to achieve orbit demonstrate the difficulties of mastering a new research technique. Results so far (save in the field of rocketry) are meagre and inconclusive. The American *Vanguard I* and *Explorer III* each contain an ingenious electronic device. One is the miniature tape-recorder, weighing only $\frac{3}{4}$lb, incorporated in *Explorer III* for the storage of cosmic-ray data collected on each two-hour orbit (see Figure). This carries 55 in. of magnetic tape geared to travel at a speed of 0·005 in./s while the data are being recorded. The tape runs through in just over two hours. Playback takes only five seconds on command as the satellite passes over the American telemetering stations arranged along the 75th parallel; the recorder then rewinds automatically and resumes the cycle.

The solar cells that are successfully operating the *Vanguard I* low-power transmitter, and are expected to do so as the satellite passes across the sunlit side of the earth for several years, likewise represent a notable advance in radio instrumentation.

There are six of them, mounted equidistantly round the satellite's hull so as to project $\frac{3}{4}$in. from the outside surface. Each cell is 2 in. square and is composed of 18 wafers of silicon arranged as a kind of sandwich. The power yield of each cell is of the order of 5 mW and feeds directly to the low-power transmitter. In the original plan, the cells were designed to trickle-charge a small chemical storage battery which would operate the transmitter continuously, irrespective of the position of the satellite in relation to the sun. The restricted payload of *Vanguard I* made it impossible to include the chemical battery in the system. The low-power transmitter therefore puts out a signal only while the satellite's path lies in the sunshine. The lifetime of the cells depends entirely on the amount of erosion that the outside surface of the satellite suffers from collision with micrometeorites.

On a basis of the performance of these solar cells it is estimated that cells with a total reflecting surface of one square yard would provide sufficient power to work a television camera.

Conclusion

It is clear from the achievements that can be reported at even this early stage that the 'Year' is proving an unqualified success. The choice of period in the sunspot cycle has been fully justified, and co-operation between the countries involved is going so well and proving so valuable that already there are schemes for extending scientific activity of all kinds on an international co-operative basis.

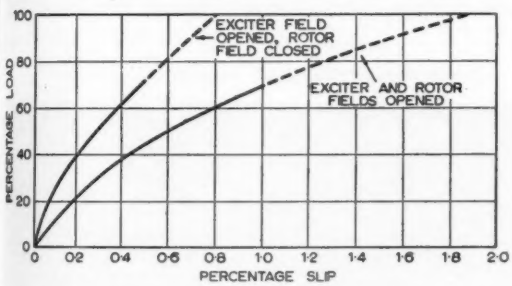
SHORT REVIEWS OF PAPERS

On the following pages are some brief review articles based on, and written by the authors of, current Institution papers. The authors have been asked to make these articles, so far as possible, interesting and of appeal to electrical engineers who have no specialized knowledge of the subjects, and the content of the articles is not necessarily confined to the subject-matter of the original papers.

Solid-Rotor Asynchronous Generators

A short review of a Supply Section paper (No. 2492) entitled 'Design and Application of Large Solid-Rotor Asynchronous Generators', by P. Richardson, Member. The paper was published individually in January 1958, and it will be republished in Part A of the Proceedings. The author is with C. A. Parsons and Co.

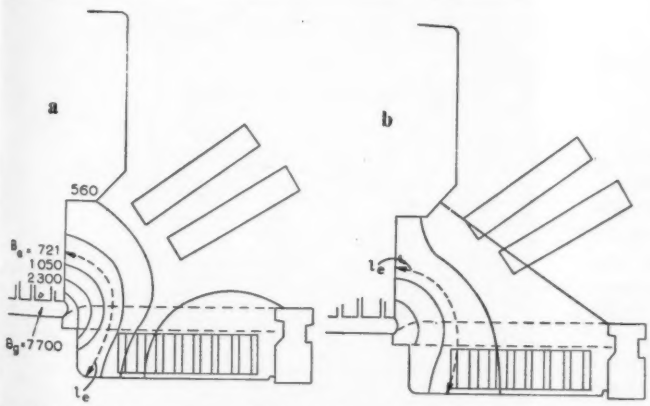
THE PRESENT STUDY WAS MADE WITH THE OBJECTS OF summarizing the problems associated with the design of asynchronous generators and of considering their application as shunt reactors or as one component of a cross-compound unit. The absence of an exciting winding on the rotor creates a leakage field problem around the stator end windings, leading to stator-core end heating similar to that experienced on a synchronous generator at a leading power factor when the excitation is weak, and also when excitation has been lost. The factors affecting core end heating have been investigated.



1 *Asynchronous operation of 2500 kW generator*

The power factor of an asynchronous machine is inherently low, and while in certain circumstances this may be turned to advantage, the problem with asynchronous generators in general is to keep the power factor high. The asynchronous generator does not carry an exciting winding and is put onto the bars of a system by running up to speed and switching in without any need for close synchronizing as with a synchronous machine. There is, however, an initial current surge similar to that which occurs when switching in a transformer. An advantage of the asynchronous generator is that under fault conditions the fault current decays rapidly and is negligible after the first one or two cycles.

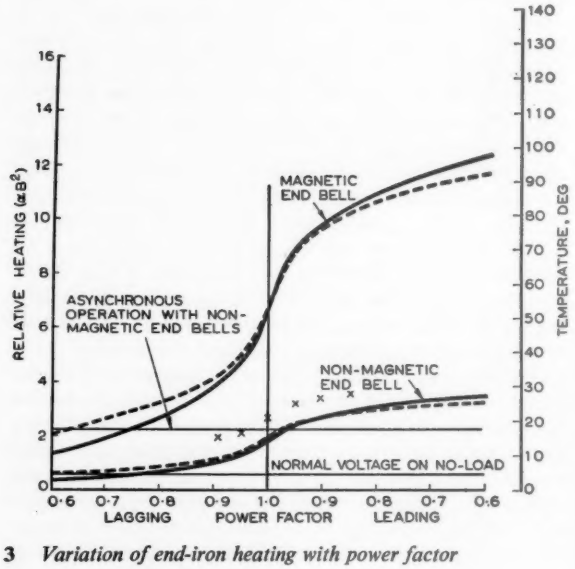
Some time ago, the author carried out tests on a 2500 kW generator. This machine was operated synchronously at a predetermined steady load, and the exciter field circuit was then broken. Readings were taken of the slip and stator currents, after which the main field circuit was broken and readings were again taken. On restoration of the original excitation conditions, the generator pulled into step without difficulty. These tests were repeated at various loads, and Fig. 1 shows the relationship between load and slip. The tests demonstrate that without excitation the losses in the rotor are of the same order as those obtaining when fully excited at rated load. In the past, generators have been known to lose excitation for various reasons, without overheating or damage to the rotor, but overheating of the stator may occur.



2 *Winding fields: non-magnetic end bells*
Power factor, 0·8. Short-circuit ratio, 0·55. a Rotor. b Stator.
B_e is the flux density of the end leakage. B_g is the flux density in the air-gap. l_e is the length of the end leakage-flux path, which is typically about 16 in.

It is believed that the analysis of stator-core end heating given in the paper is of sufficient accuracy to illustrate the manner in which the heating is influenced by power factor, excitation, short-circuit ratio and material of the rotor end bell. The end leakage flux has two components. The first is the end leakage on the assumption that the magnetic circuit is energized from the rotor only; this component is related to the gap flux density and is substantially constant. The second

component is the end leakage on the assumption that the magnetic circuit is energized from the stator only; this depends in magnitude on the stator current. These components can be called the *rotor winding field* and *stator winding field* respectively, and Fig. 2 shows simplified flux plots of these fields at the end of a generator having non-magnetic rotor end bells. The resultant field, i.e. that which causes core end heating, depends on the magnitude and phase of the two components. That this end leakage-flux field can cause overheating of the core end sections of generators has long been recognized, and curves showing how the intensity of heating varies with power factor have been published. Where magnetic rotor end bells are used, it is shown that there is a marked increase in loss intensity compared with figures obtained with non-magnetic end bells, and Fig. 3 shows the relative heating curves.



3 *Variation of end-iron heating with power factor*

——— Short-circuit ratio, 0·55.
– – – – Short-circuit ratio, 1·0.
× Test points measured on 60 MVA generator with non-magnetic end bells.

There are some applications for which the asynchronous generator is particularly suitable. For example, where the stability problem associated with long transmission lines necessitates the employment of shunt reactors, it would seem possible to make use of the asynchronous generator, which relies on the capacitance of an overhead line (or other synchronous plant) to provide its excitation. Another application is in large cross-compound turbo-generator sets, where an asynchronous machine can operate alongside a synchronous machine and derive its excitation from the latter. The asynchronous generator is very suitable for the high-speed line, for the rotor can be of simple robust construction.

621.313.332

Effect of Arc Furnace on Electricity Supply

A short review of a Utilization Section paper (No. 2456) entitled 'Supply-Voltage and Current Variations produced by a 60-ton 3-phase Electric Arc Furnace', by B. C. Robinson, M.Sc., Ph.D., Member, and A. I. Winder. The paper was published individually in December 1957, and it will be republished in Part A of the Proceedings. The authors are with C. A. Parsons and Co.

ELECTRIC ARC FURNACES HAVE BEEN USED SINCE ABOUT 1910 for the production of high-grade steel alloys. As these have usually been relatively small units, it has been economical to use them only for the more expensive alloys. However, larger units have now been developed, and in December 1954 a furnace designed to take a charge of 60 tons of scrap metal went into production near Sheffield.

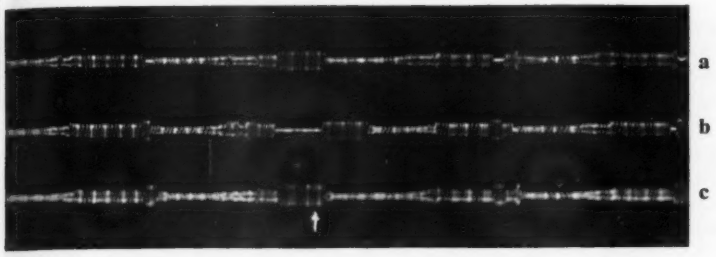
As various experiences of over-voltages and voltage fluctuations had been reported on other furnaces, it was decided to carry out an investigation into the effects of this furnace on the supply system, which, at that time, formed a temporary tee on the 66 kV network.

The furnace, which is shown in Fig. 1, consists of a crucible with a slightly convex (domed) lid. The latter

1 *A 60-ton 3-phase electric arc furnace*

can be swung to one side, permitting the scrap-metal charge to be dropped into the crucible. Power is supplied to the furnace by means of three carbon electrodes 20 in. in diameter passing through the furnace roof. Arcing takes place between the charge and these electrodes, which are connected by heavy-current flexible leads to a 15 MVA transformer with an output of 90–325 volts.

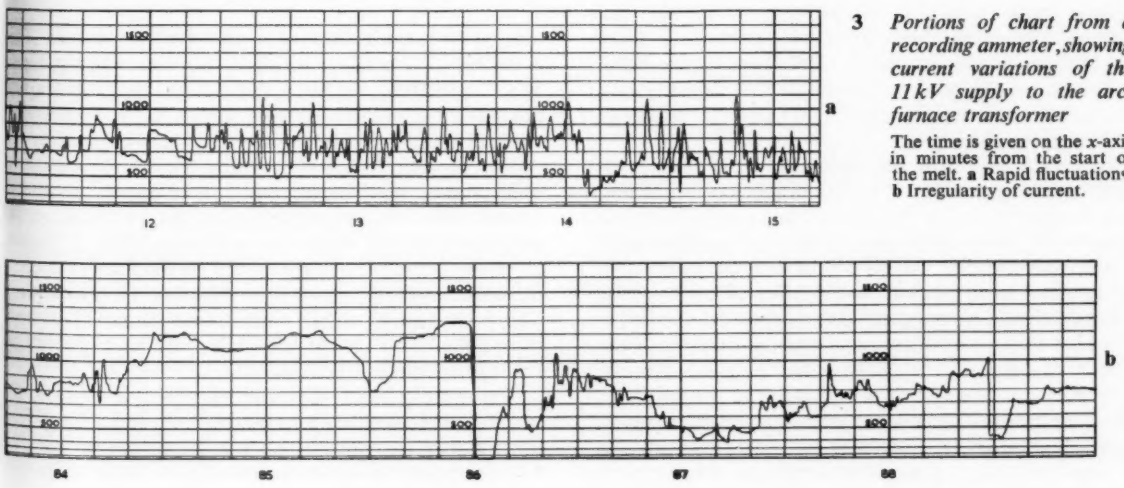
When the furnace is first switched on after recharging, arcing is very spasmodic and irregular owing to the cold and heterogeneous nature of the charge. Initially the electrodes bore down into the charge as the metal below them melts. The sides of the holes thus produced may then collapse, producing temporary short-circuits on the arcs. Alternatively, in the event of a heavy current surge, the automatic electrode control gear may overrun and extinguish an arc, causing the transformer to operate on two phases. Typical variations of the arc voltage about 3 min after switching on are shown in Fig. 2. Actually this oscillogram gives the voltage at the electrode clamps relative to an electrode buried in the furnace bed or brickwork. It therefore includes the voltage drop in the electrodes themselves. At this stage of the melt the arc current as indicated on supervisory ammeters varied from zero to over 40 kA.



2 *Oscillogram showing variation of arc voltages 3 min after switching on*
Duration of record: 7sec.
Voltages at arrow:
a Red phase, 225 volts. b Yellow phase, 39 volts. c Blue phase, 166 volts.

The furnace transformer was supplied at 11 kV from a star-connected 66/11 kV 15 MVA transformer. Most of the measurements were carried out at the 11 kV level, since all the furnace metering was done at this voltage. Fig. 3 shows typical records of the current during the melting of the charge, the actual times being given in minutes from switching on. Fig. 3*a* shows continuous fluctuations with about 10–15 peaks per minute, though other records taken show voltage and current fluctuations with a rate of about 75 per minute. Fig. 3*b* shows the irregular nature of the current variations, which may include changes of a thousand amperes in a few seconds. These currents are not balanced but each phase can vary independently, subject to the condition that the total instantaneous current in all phases must be zero. These wide and rapid changes in load current cause variations in the line voltage drop due to the line impedance. They will therefore affect other equipment connected to the network.

The relationship between the arc voltage and current is dependent on the electrode spacing and the temperature, among other factors. The arc-voltage waveform is therefore determined by this characteristic and not by the supply. The difference between the arc voltage and the supply voltage is absorbed by the circuit impedances, i.e. transformer and line reactances. These differences in waveform may cause voltages in excess of the normal line voltage to appear across the terminals of the furnace transformer, especially when unsymmetrical arcing conditions occur. An approximate analysis of these, and an estimation of the voltages obtained, may be made by



3 *Portions of chart from a recording ammeter, showing current variations of the 11 kV supply to the arc-furnace transformer*
The time is given on the *x*-axis in minutes from the start of the melt. a Rapid fluctuations. b Irregularity of current.

assuming that the arc waveform is rectangular. The waveforms thus obtained are compared with others taken during the tests. They show that theoretically the peak transformer terminal voltage may be greater on load than on open-circuit.

During the tests continuous oscillograms were taken of the furnace transformer voltage to earth on all three phases for periods of about 45 min duration. These indicated that voltage variations between about 75% and 150% of normal open-circuit voltage were obtained. They also showed that the excess voltages occurred only for very short periods, often for about one or two half-cycles. Theoretical calculations showed that similar voltages would occur across the furnace transformer primary winding which was delta connected.

Calculation of the various line and transformer impedances indicated that the voltage fluctuations in the 66 kV system would be about 17% of those on the 11 kV terminals. This would mean that the maximum amplitude of the supply-voltage fluctuations on the 66 kV system would be about 4%. The authors noticed that they could detect the start-up of the furnace by watching the electric lights at a point about 2 miles from the furnace, though this was not detected by the residents. Since the tests, a lower-impedance supply to the furnace has been obtained from a neighbouring 132 kV line.

621.365.2 : 621.3.016.33

Medium-Voltage H.B.C. Fuses

A short review of a Utilization Section paper (No. 2419) entitled 'Recent Developments in Medium-Voltage H.B.C. Fuse Links', by R. H. Dean, B.Sc.Tech., Member. The paper was published individually in October 1957, and it is republished this month in Part A of the Proceedings. The author is with Parmiter, Hope and Sugden Ltd.

A BREAKING CAPACITY OF 100 KA ASYMMETRICAL ON 600 volts seems high by British standards, but the Canadian Standards Association, in publishing their Code 106, were wise to specify this large figure, since with modern techniques fuse links of this capacity can be manufactured inexpensively in quite small dimensions, as demonstrated in Fig. 1.

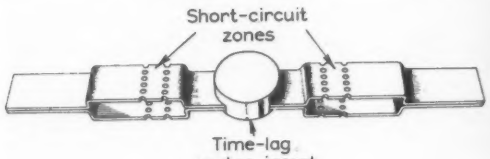
Regulations in North America also insist that fuses should operate on a 35% overload within a certain time. The practice in Great Britain of using semi-enclosed (copper-wire) fuses which do not blow in practice until the overload exceeds 100% would not be acceptable because there is no protection on faults of up to twice the rating. North American engineers consider this a fire risk, which their simple fuse requirements have removed.

The dual-element type of fuse link (Fig. 2) satisfies their requirements, and this design received the approval of the Canadian Standards Association. High breaking capacity is obtained by a series of perforations to provide the maximum arc area. This original development

1 *Modern high-breaking-capacity fuses*
30 and 60 amp fuse links, with a breaking capacity of 100 kA at 600 volts.

reduces the amount of metal involved in the operation of the fuse link on severe faults, so that both the time of operation and the amount of fault energy allowed to flow are correspondingly reduced. The fuse starts to limit at twenty times its current rating and thereafter limits the admitted current in the ratio of the cube root of the prospective current.

The centre insert for operating on overloads is of interest, its function being illustrated in Fig. 3. The tin-

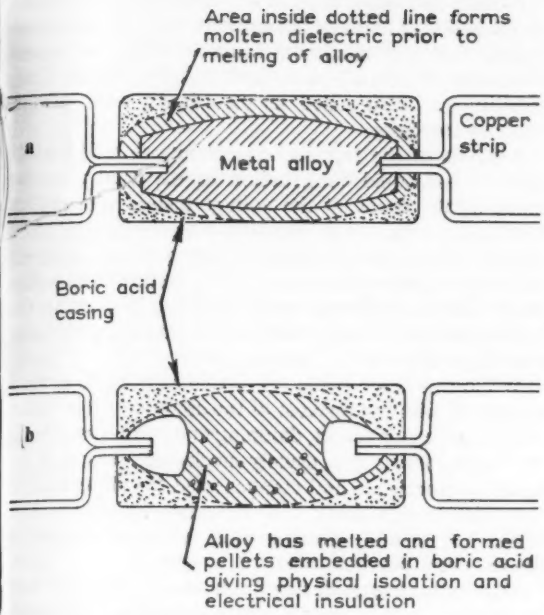


2 *Dual-element strip*

lead alloy is embedded in a casing of boric acid. This melts before the alloy, which is then immersed in liquid flux. On blowing, the alloy metal runs into globules, and the current is broken by separation and by the electrical insulation of the separate globules by the boric acid.

The problem of weakening in service, or ageing, is overcome in this design, and in the paper the author quotes tests to demonstrate that no overload, either continuous at 5% below the minimum blowing current, or in the form of repeated surges of the kind that occur in motor starting, alters the resistance of the element. This is important where correct discrimination between fuse links, or between the fuse link and the motor starting equipment, is required.

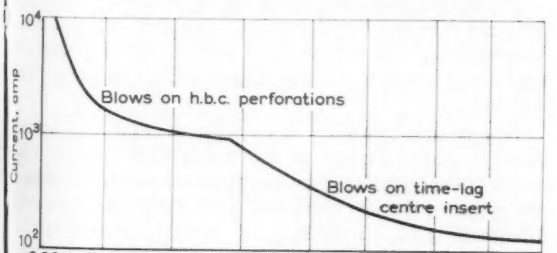
The time/current characteristics are shown in the curve of Fig. 4. The fuse will blow on a 25% overload after a period of hours, on five times the rating after 5 sec, and on ten times the rating in under 1 sec. The


Area inside dotted line forms molten dielectric prior to melting of alloy
a
Metal alloy
Copper strip
Boric acid casing
b
Alloy has melted and formed pellets embedded in boric acid giving physical isolation and electrical insulation

3 *Operation of the time-lag centre insert*
a Before breaking. b After breaking.

discontinuity in the curve shows the change from blowing on the centre insert to blowing on the high-breaking-capacity perforations. Above ten times the rating, the time lag is short, because such currents represent faults requiring quick clearing.

In Great Britain, engineers have tacitly assumed that a high-breaking-capacity fuse link automatically limits



4 *Time taken for a dual-element fuse to blow*
The rating of the fuse is 100 amp.

the energy passed on a severe fault, so that no damage, either from magnetic forces or from heating, can occur. Their North American counterparts require this to be proved, and the author gives a simple method of establishing the ratio of the power (and from this the energy) that actually does flow on a fault to that which potentially could flow. The following figures may be of interest as examples of the limitation provided. Fault-current limitation commences at about twenty times the current rating of the fuse link. A 100 amp fuse link on a fault of 10 kA passes less than 1/23rd of the energy that would be circulated by a non-limiting form of protection such as a circuit-breaker. On 50 kA, only 1/500th of the energy would circulate. 621.316.923

Stability Tests on the 132 kV Grid

A short review of a Supply Section paper (No. 2575) entitled 'Results of Full-Scale Stability Tests on the British 132 kV Grid System', by F. Busemann, Dr.Ing., Associate Member, and W. Casson, Member. The paper was published individually in February 1958, and it will be republished in Part A of the Proceedings. Dr. Busemann is with the British Electrical and Allied Industries Research Association, and Mr. Casson is with the Central Electricity Generating Board.

THE STABILITY OF POWER SYSTEMS DEPENDS ON A NUMBER of factors which the system designer must consider in network analyser studies. In view of the importance of the decisions made on the basis of such studies, the E.R.A. and the then Central Electricity Authority co-operated in a programme of tests on the 132 kV Grid system carried out during four days in August 1956 at the Cliff Quay (Ipswich) generating station of the Eastern Division. The main purpose of these tests was a comparison of the actual performance of a 56 MVA test generator on the system during transient faults with forecasts made on network analysers.

The transient-stability tests made on the system and the principal results obtained are listed in the Table,

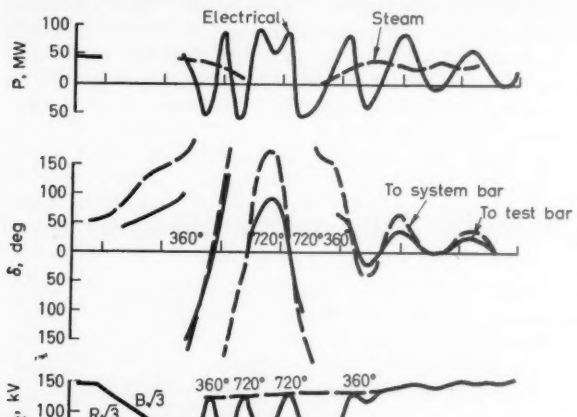
Transient Fault Tests on the System

Test number	1·1	1·2	1·3	1·4	1·5	1·6
Fault	LG	LL	LL	LL	LLL	LLL
Distance, miles ..	13	0	0	0	0	0
Load, MW ..	45	45	45	45	30	45
Load, MVA ..	7·9	9·7	9·6	9·5	7·2	9·7
Voltage regulator	with	with	with	without	with	with
Fault time, sec. Test ..	0·62	1·28	0·96	0·98	0·68	0·32
Fault time, sec. Analyser	∞	~1·15	—	—	0·51	0·36
Fault time, sec. Micro-réseau ..	∞	1·32	—	—	0·9	0·4
Test condition ..	stable	unstable	stable	stable	unstable	stable

which includes the calculated critical fault-clearing times as forecast by preliminary studies on a.c. network analysers and on the micro-réseau of Électricité de France.

During a line-to-ground (LG) fault 13 miles away for 0·62 sec, conditions were stable, as forecast by both network analysers and micro-réseau.

On a close-up 2-phase fault for 1·28 sec, instability occurred, as forecast by the network analysers. Fig. 1

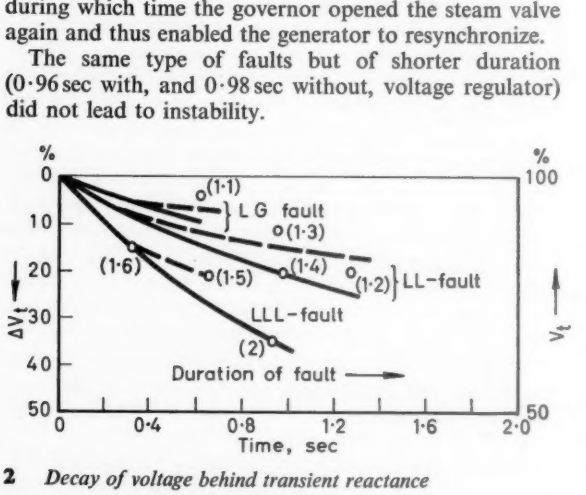


1 *Records of Test No. 1·2*

Close-up phase-to-phase fault for 1·28 sec.
Voltage regulator in commission.

shows recordings taken during this test. Immediately after the fault the generator slipped two pole-pairs forwards. By that time the governor had cut off the steam input and the generator slipped one pole-pair backwards, during which time the governor opened the steam valve again and thus enabled the generator to resynchronize.

The same type of faults but of shorter duration (0·96 sec with, and 0·98 sec without, voltage regulator) did not lead to instability.



2 *Decay of voltage behind transient reactance*

——— Without voltage regulator.
— — — With voltage regulator.

A close-up 3-phase fault at two-thirds load for 0·68 sec, about half-way between the network analyser and micro-reseau values of maximum fault-clearing time, caused instability; but on a 3-phase fault at full load for 0·32 sec, stability was maintained in accordance with network-analyser forecasts.

Analysis of the transient-test results showed that the greatest individual contribution to the total error was made by the decay of the voltage behind the transient reactance, which was measured approximately from voltage recordings at instants during swings after the fault when the current was zero. Fig. 2 shows this voltage decay for the different types of fault. The decay was reduced by the voltage regulator on faults lasting longer than 0·3 sec.

While this error made the actual performance worse compared with the forecast of the analyser, other factors such as governor action, damping and extra losses during the fault, which are usually neglected, improved the actual performance and compensated for about half the error due to flux decay, thus reducing the total error to about 5% in fault clearing time, which is tolerable in almost every practical case.

The extra losses during fault were estimated from rotor-angle measurements made during a short-circuit test on the isolated generator at no-load. The effective total retarding torque of the alternator losses during fault is about twice that caused by the copper losses in the stator due to the symmetrical a.c. component of the fault current. This is less than was expected from preliminary studies on the micro-réseau.

The transient and subtransient reactances obtained from the fault recordings are in good agreement with values from works tests. Tolerances of 10–20% of these values would affect the accuracy of fault-clearing-time calculations by only about 1·5–3%.

During transient tests, with sudden insertion of the line between generator and system, instability did not occur provided that the field current prior to the line insertion was large enough for the steady-state conditions with the line.

Steady-state stability tests showed that the leading reactive power carried at the steady-state stability limit is somewhat greater than the theoretical value obtained for cylindrical-rotor machines from the unsaturated value of synchronous reactance.

Steady-state conditions of the alternator transmitting its output through the line proved to be very stable when the voltage regulator was in service. It was then almost impossible to produce pole-slipping. When the machine had reached a power angle of about 120° the voltage regulator usually pulled it back below 90°.

Asynchronous operation with open field was tried with loads up to 30 MW direct and with a load of 10 MW through the line. The measured slip was remarkably low, less than 0·3% at 30 MW—a sign that the rotor must have found a low-resistance path for the current outside the open field winding.

The Cliff Quay stability tests have given valuable

information on the transient and steady-state performances of modern British equipment in actual service conditions, and have confirmed that the results of transient network analyser studies are in reasonable agreement with actual performance, since a number of factors, such as damping, governor action and extra losses during fault improve the actual performance and cancel out most of the effect of flux decay which worsens it. Governor action of the steam turbine did not much contribute to the first swing after the fault, but it was very effective in resynchronization once pole-slipping had occurred. The voltage regulator had a beneficial effect on transient stability when faults persisted for more than 0·3 sec. In the steady-state transmission of power through the line, the stability was well maintained by the voltage regulator. 621.315.1.016.35

Large-Scale Grid Tests

A short review of a Supply Section paper (No. 2559) entitled 'The Organization of Large-Scale Grid System Tests', by F. H. Last, Ph.D., B.Sc.(Eng.), Associate Member, E. Mills, Associate Member, and N. D. Norris, Associate Member. The paper was published individually in February 1958, and it will be republished in Part A of the Proceedings. The authors are with the Eastern Division of the Eastern London and South Eastern Region of the Central Electricity Generating Board.

THE STABILITY OF GENERATING PLANT ON A LARGE INTERconnected system is an important consideration in design and operation, and tests on an operational system are very desirable in proving that the fundamental design technique is sound. The paper outlines the organization adopted to study generator steady-state and transient stability on the British Grid system under controlled conditions.

The Cliff Quay generating station at Ipswich was chosen because the desired system and plant conditions could be readily obtained. Tests were made to study:

(1) The steady-state stability of a generator connected directly and through a long transmission line to the system.

(2) The transient stability of a generator after the sudden insertion of a high line reactance in the system.

(3) The transient stability of a generator under applied fault conditions.

The effect of automatic voltage regulators on the performance of a generator was also examined.

Certain steps had to be taken to safeguard both supplies to consumers and the plant. The tests required special arrangements of the system, and the operating procedure used demonstrates the system operation requirements, the safety regulations, and the control of plant necessary to achieve the required test conditions and results.

In addition, special communication facilities and protective-gear modifications were necessary. The need for giving particular consideration to 'system' as distinct from 'laboratory' tests was forcefully demonstrated by the occurrence of system faults during the testing sequence.

The following conclusions are drawn:

In system tests it is essential to draw up a programme and adhere to it, because any modifications, however slight, may delay the proceedings. Adequate communication, independent of the operational system, is very valuable, and a closed-circuit television installation can be most useful in giving the control-room staff a picture of conditions on the test turbine.

Some operational risks are unavoidable, but they must all be carefully considered, and the possibility of fault conditions must not be ignored.

The tests demonstrated that the normal generator control-panel instruments are inadequate and can give misleading information during unstable conditions. They also showed the usefulness of rotor-angle indication or recording in a large generating station where instability is likely to occur. These indications are invaluable in informing the operating engineer which generator has an oscillating rotor and in telling him if corrective action is necessary and, if so, whether the action is having the desired effect.

The tests showed that operational staff at large generating stations could benefit from training to meet and correct generator-instability conditions. This could be achieved in some measure by organizing small-scale demonstrations at stations where instability may arise.

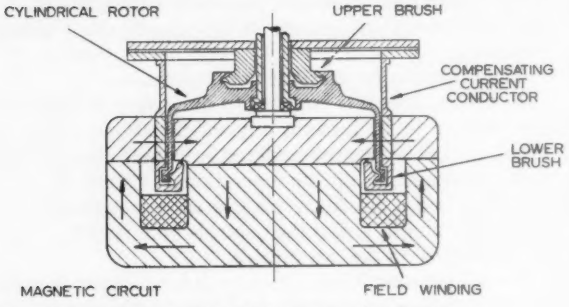
621.311.016.35 : 621.316.91

Homopolar Generator with Mercury Brushes

A short review of a Utilization Section paper (No. 2606) entitled 'The Development and Operation of a 10 kW Homopolar Generator with Mercury Brushes', by D. A. Watt, B.Sc.(Eng.), Associate Member. The paper is published this month in Part A of the Proceedings. The author is at the Atomic Energy Research Establishment, Harwell.

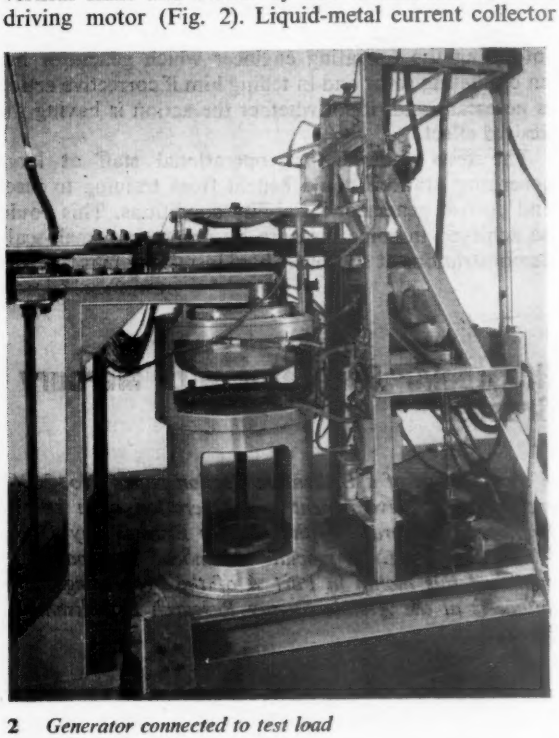
THE HOMOPOLAR, OR UNIPOLAR, GENERATOR IS FREQUENTLY mentioned in technical literature as a source of large direct currents and for its value in illustrating basic principles of electromagnetic induction. The present paper describes a small machine developed to establish principles of design of homopolar generators for the efficient production of the large currents required for the d.c. electromagnetic pump. D.C. electromagnetic pumps offer a very satisfactory method of propulsion for the high-temperature radioactive liquid-metal coolants proposed for certain types of nuclear reactor. A large pump may require more than 100 kA at 2 or 3 volts.

The experimental generator is shown diagrammatically in Fig. 1. The magnetic circuit is shaped like a large



1 *Homopolar generator with mercury brush rings*

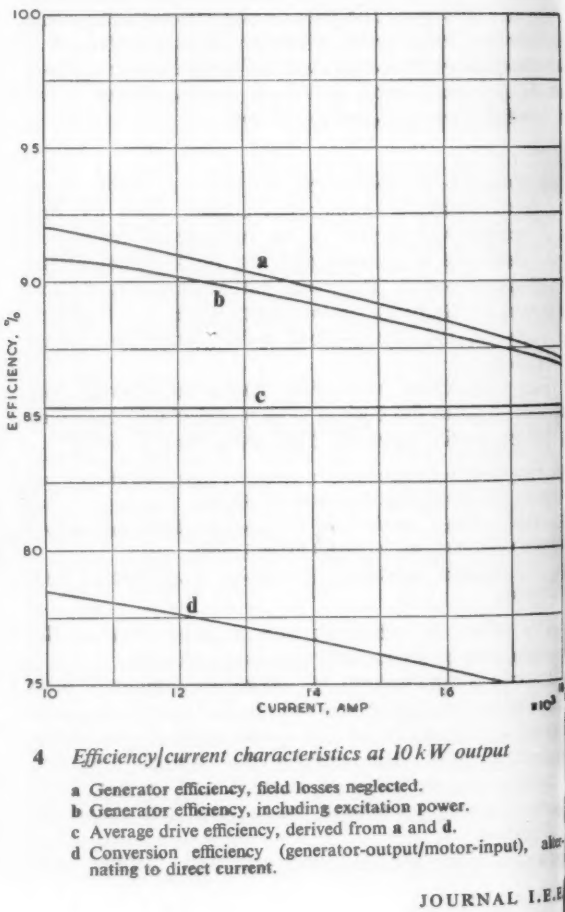
loudspeaker magnet, and a cylindrical copper rotor is mounted in the annular gap. The rotor is carried on a vertical shaft and driven by belt connection with the driving motor (Fig. 2). Liquid-metal current collector



2 *Generator connected to test load*

rings or 'brushes' are arranged on the rotor near each end of the magnet gap. Each brush consists of a circular channel between the moving and stationary members. In section this channel is concave towards the axis of rotation and so can be filled with mercury when the machine is running. Copper is the best material for the brushes, but it must be protected from erosion by a thick layer of nickel plating. A rhodium finish on the nickel

3 *Copper rotor and brush assembly*



4 *Efficiency/current characteristics at 10 kW output*

- **a** Generator efficiency, field losses neglected.
- **b** Generator efficiency, including excitation power.
- **c** Average drive efficiency, derived from **a** and **d**.
- **d** Conversion efficiency (generator-output/motor-input), alternating to direct current.

ensures excellent electrical contact with the mercury. Fig. 3 is a photograph of the rotor bell and brushes.

The design of the machine was preceded by an extensive experimental study of brush friction and behaviour. The results of this were incorporated in a design study from which the leading dimensions of the machine were decided. Sodium–potassium alloy was considered as a brush liquid, but although it could offer even smaller brush-friction and ohmic losses this advantage was outweighed by considerations of experimental convenience and the more satisfactory limits of brush stability obtained with mercury. The passage of a heavy current through the brush liquid tends to move it out of the channel under the self-pumping action of the current in its own field. This is analogous to the pinch effect in a liquid conductor. In the experimental machine the estimated stability limits are many times greater than the full-load current of 10–16 kA at 1·0–0·625 volt. The efficiency/current characteristics are shown in Fig. 4. At 10 kA 1-volt output the generator efficiency exceeds 90%. In machines of about 100 kW rating at 2 or 3 volts, an efficiency of 95% could be expected.

In a large machine it is preferable to make the whole centre-pole rotate and allow the current to pass axially through the rotor iron. With brush speeds of about 45 ft/sec and angular speed of about 500 r.p.m. the maximum potential difference which can be obtained from a single unit with solid conducting rotor is about 3½ volts. Provided that friction losses are of reasonable proportions, there is no intrinsic reason why much higher speeds should not be used. Experimental study would establish the requirements for satisfactory brush behaviour and the friction loss incurred. A design study for a large generator has been undertaken for the U.K.A.E.A.

This class of machine was developed as a current supply for the d.c. electromagnetic pump, but the availability of large direct currents in so compact a form may also have advantages for industrial and research projects.

621.313.291.1–8

SYNOPSES OF PAPERS

The following are synopses of papers published in the *Proceedings* which have not been read at an Institution meeting and which have not been described under 'Short Reviews of Papers'. They are included here primarily for reference. The papers have not been published individually, as have those for reading at meetings, but reprints of them will be available shortly (see p. 328).

Transformers, Regulators and Reactors

A synopsis of a review of progress (Paper No. 2611) with the above title, by E. T. Norris, Member. The paper is published this month in Part A of the Proceedings. The author is a consulting engineer with Ferranti Ltd.

THE REVIEW COVERS DEVELOPMENTS AND PROGRESS during the six years since the last one in 1952.* There have been, during this period, outstanding improvements in both design and construction of transformers, and an unusual increase in maximum size and rating as regards both voltage and apparent power. This has been due partly to the inauguration of the 275 kV British Supergrid system and partly to the demand from abroad for large transformers in the 300–400 kV range.

The outstanding development, affecting transformers of all sizes, results from the general industrial use of cold-rolled grain-oriented steel, as distinct from the limited application described in the last review. Considerably higher flux densities can be employed, with a substantial reduction in weight and size of the transformer and in both its iron and its copper losses.

The review discusses the changes in core construction and in manufacturing technique required to realize these improvements. Impulse testing has become accepted practice, with assurance of fault detection on both full and chopped waves. Noise is still a recurrent problem. For the larger transformers, with separate cooling banks, a relatively economical and practical construction reducing the noise by about 20 dB has been devised by the Central Electricity Generating Board.

Digital computers have become a new aid to design calculations and seem likely to eliminate much routine mental drudgery as, in due course, methods of design are adapted to suit computer techniques.

The remarkable increase in size of large power transformers has accentuated difficulties due to transport restrictions and led, among other things, to the introduction of 3-dimensional contour tanks. In the transformer itself mechanical stresses on short-circuits have increased, due not only to the higher apparent power but also to increasingly severe system short-circuit conditions. The effect of these stresses is progressive and sometimes cumulative and can be expressed in an estimated expectation of life.

The increasing use of auto-transformers for superimposing higher-voltage systems on existing networks has demanded on-load tap-changing gear insulated for these voltages, even for direct connection at the live terminals. British makers have produced entirely new designs to meet these requirements.

The constructional standardization of distribution transformers by the Area Boards has brought inter-

* NORRIS, E. T.: 'Electrical Plant and Machinery: Transformers, Regulators and Reactors', *Proceedings I.E.E.*, Paper No. 1245, March 1952 (99, Part I, p. 68).

changeability and, by permitting batch production and the use of jigs and templates, has greatly simplified manufacture.

Dry-type distribution transformers, using the new synthetic resin and plastic insulating materials and capable of withstanding much higher temperatures, have been developed by many manufacturers. The thermal rating of these materials is, however, proving very complex and difficult. National efforts are being made to resolve the problem.

Other matters dealt with in the review include recent developments in voltage regulators; reactors; mining-type transformers; rectifier transformers, including the new locomotive transformers for traction; furnace transformers; and high-voltage testing transformers.

621.314.2

Conjugate-Impedance Network Analyser

A synopsis of a Supply Section paper (No. 2607) entitled 'A Conjugate-Impedance Network Analyser operating at 50 c/s', by W. Casson, Member, and A. W. Hales, Associate Member. The paper is published this month in Part A of the Proceedings. The authors are with the Central Electricity Generating Board.

THE PAPER OUTLINES THE DESIGN AND PERFORMANCE OF an economical conjugate-impedance type of network analyser operating at 50 c/s. The development of the analyser involved, amongst other things, the design and development of a composite equipment for the measurement of voltage, current, real power, reactive power, phase angles, and—when used in conjunction with a calibration source—the calibration of the shunt and series impedance elements used in the analyser. A comparison between the data obtained by measurements from the network analyser and rigorous calculations for four types of problem is given.

621.317.79

Fractional-Slot Windings

A synopsis of a Supply Section paper (No. 2678) entitled 'Design of Fractional Slot Windings', by J. H. Walker, M.Sc., Ph.D., Member, and N. Kerruish, M.A. The paper will be published in Part A of the Proceedings. The authors are with the British Thomson-Houston Co.

A THEORY IS DEVELOPED BY WHICH THE ELECTRICAL design of a standard fractional-slot winding may be readily established. Formulae are given for the calculation of the amplitude of the fundamental and the various harmonics, and three methods are developed for reducing the amplitude of any particular harmonic. The noise produced by the vibration of the core set up by the lowest sub-harmonics is briefly discussed. A worked example shows, *inter alia*, a practical method of designing suitable end connections for fractional-slot wave windings.

621.313.1.045.1

Effect of Voltage Regulator on Stability of Synchronous Generator

A synopsis of a Supply Section paper (No. 2662) entitled 'The Effect of a Voltage Regulator on the Steady-State and Transient Stability of a Synchronous Generator', by A. S. Aldred, M.Sc., Associate Member, and G. Shackshaft, B.Eng., Graduate. The paper will be published in Part A of the Proceedings. The authors are in the Department of Electrical Engineering, University of Liverpool.

THE PAPER IS CONCERNED WITH PREDICTING THE STEADY-state, dynamic and transient stability of a synchronous generator, with a voltage regulator, when coupled to an infinite busbar. The effect of the main regulator loop parameters, such as gain, exciter and main field time-constants on the stability of the system are examined. The ideal stability boundary for a particular system is defined, and attempts are made, by the introduction of subsidiary feedback and series networks, to obtain the ideal characteristic. The influence of the transient reactance on stability and the effect of minimizing this parameter are considered. New voltage-excitation characteristics are described which have been found useful for predetermining power-angle curves for a machine with a voltage regulator and for checking computer solutions of steady-state stability boundaries.

621.313.322.016.35 : 621.316.722

Electronic Power-System Simulator

A synopsis of a Supply Section paper (No. 2673) entitled 'An Experimental Electronic Power-System Simulator', by K. G. Corless, B.Eng., and A. S. Aldred, M.Sc., Associate Member. The paper will be published in Part A of the Proceedings. The authors are in the Department of Electrical Engineering, University of Liverpool.

THE PROBLEM OF POWER-SYSTEM SIMULATION IS APPROACHED by considering the system as an integrated physical interconnection of generators, transmission network and load. A d.c. electronic analogue computer for synchronous-machine representation which invokes the minimum number of assumptions is coupled to a high-frequency impedance analogue for the transmission network, to form a composite system simulator. To facilitate the study of simulation techniques the power system is reduced to the basic two-machine configuration. This preserves the essential characteristics of a synchronous system and ensures that the techniques will be applicable to a multi-machine simulator. The paper describes the simulator and concludes with some solutions of representative problems.

621.317.79 : 621.311.1

OBITUARY

JAMES WILLIAM ATKINSON

James William Atkinson, I.S.O., who was born on the 16th September 1878, died suddenly on the 27th November 1957, when on a visit to London from Atherton, near Manchester, where he lived. He went to school in Manchester and later studied part-time at the Manchester College of Technology, while receiving practical training with the British Westinghouse and Electrical Manufacturing Co.

He entered the Post Office in April 1893 as a telegraph learner and spent the whole of his working life in various activities connected with telecommunication, until his retirement in February 1944 as Deputy Regional Director of the North Eastern Region at Leeds. His career was marked with a desire to place the Post Office communication service in an unparalleled world position, and he gave much attention to accurate detail in all phases of his work. This perhaps accounts for his extreme interest in The Institution of Post Office Electrical Engineers. He was Secretary of its formation committee and of that Institution itself for the first two years of its existence. Since then he had served as Honorary Treasurer and as a Member of the Council of the same Institution, and he was elected an Honorary Member in 1944. He had also served as Chairman of the Board of Editors of the *Post Office Electrical Engineers' Journal*.

He had a very likeable personality and a deep sense of the human problems of his colleagues, many of whom must have benefited from his wise counsel. From the manner in which he accepted and discharged his responsibilities, he clearly placed integrity as one of the highest virtues.

In his spare time he devoted most of his energy to gardening, but in later years, particularly when he had retired, he had two main hobbies: one was to work through the *Post Office Electrical Engineers' Journal* (of which he possessed a copy of every volume published) extracting information for a history of the Post Office Institution which he proposed to write; the other was to file a comprehensive collection of Press cuttings over a period of some forty years. Unfortunately, his death prevented completion of his history.

He had a remarkable memory for names and places. In his younger days he was an enthusiastic cyclist and walker; there are few counties in Britain with which he was not familiar, and his interest in the countryside and its inhabitants brought him many friends. He was a staunch supporter of the Unitarian Church, and throughout his life, wherever his official duties took him, he freely gave his services in helping to organize and support the Church and its various clubs and societies.

He leaves two daughters and a son, his wife having died in October 1955.

He joined The Institution as an Associate Member in 1912 and was elected a Member in 1922. He served on the North Midland Centre Committee from 1930 to 1932 and from 1936 to 1938, and was Chairman from 1938 to 1941. W. F. S.

JOHN DUTTON BILLINGTON

John Dutton Billington, who died on the 13th November 1957, was born on the 24th January 1881. He was educated at Newport School, Salop, and Lucton School, Hereford, after which he entered a 3-year indentured pupilage with P. R. Jackson and Co., Salford, with part-time study at Salford and Manchester technical schools.

On the completion of his course in 1901 he joined Messrs. Lacey, Sillar and Leigh, Manchester, as Assistant Engineer. In 1910 he was appointed Assistant to the Chief Electrical Engineer with the London and North Western Railway Co., ultimately becoming Assistant for Lighting and Power Electrical Schemes, in which capacity he was responsible for all electrical schemes on the London and North Western Railway and later the London, Midland and Scottish Railway. He retired from the Company in 1935 but occasionally did electrical exhibition work for the British Electrical Development Association.

His main interest was the Dickens Fellowship, of which he was an active member, and where he met his second wife.

Mr. Billington joined The Institution as a Student in 1900 and was elected an Associate Member in 1908 and a Member in 1922. He was also a Member of The Institution of Mechanical Engineers. J. F. H.

HUGH BOURNE

Hugh Bourne, who, after a long period of poor health, died on the 11th November 1957 in the Royal Masonic Hospital, London, was born on the 17th December 1878.

He was educated in Cheadle and Manchester, where he gained as well some early experience with the Post Office Engineering Department. He then moved to London and in 1898 became a pupil with a consulting engineer, Mr. Albion T. Snell, also attending Finsbury Technical College in the evenings. In 1902 he was appointed Chief Assistant to Mr. Snell.

Mr. Snell formed a partnership in 1920, which included Mr. Bourne and Mr. Maurice G. Bland, a nephew of Mr. Snell. After the death of Mr. Snell the two others carried on the business until 1942, when the partnership was dissolved by mutual consent. Mr. Bourne then continued to practise on his own as a consulting engineer in Richmond, Surrey.

In his younger days Mr. Bourne assisted as consultant to Olympia, in connection with both the engineering and London County Council requirements for the building of the new halls, and the numerous exhibition services. He was also retained as consultant for many years by several oil companies on electrical installation and survey work in their refineries and main distribution depots. He claimed to be the pioneer in introducing to this country the h.t. electrode boiler for heating installations, the first being installed in the Commercial Union Building in Cornhill, London, where an 'all electrical' building was required, after which he was responsible for a number of similar boiler installations. Whatever he undertook was well and truly done, and his reports and estimates were carefully considered and very accurate. He had experience as an expert witness in legal cases and investigated and reported on cases of explosion and ensuing damage.

He was fond of cycling, motoring, golf and billiards, until failing sight caused him to give these up. He was a keen freemason and acted as consultant for the engineering equipment when the Royal Masonic Institution for Boys was built at Bushey. He is survived by his widow.

Mr. Bourne joined The Institution as an Associate Member in 1903 and was elected a Member in 1911. He was also a member of the Association of Consulting Engineers and of The Institution of Heating and Ventilating Engineers. N. B. P.

ERIC HAROLD S. BULLEN

Eric Harold S. Bullen, who died on the 10th February 1958, was born in Eastleigh on the 28th March 1897. He was educated there and then received his practical training with the London and South Western Railway Co., attending their Technical Institute part-time. He served with the Hampshire Regiment in India during the 1914–18 War and on returning home attended the Military School of Science, Dublin, for a year.

In 1919 he joined the combined contracts staff of Pirelli-General Cable Works Ltd., Southampton, and in 1920 joined Callender's Cable and Construction Co. for a brief period as Assistant Engineer, Outside Testing Department. In 1922 he returned to Pirelli-General as an outside engineer in the Telephone Cable Department, where

he worked on telephone cable contracts all over the country. In 1928 he transferred to the London office of the company as an outside representative and was assistant to the London Manager, whom he succeeded in 1929. He had to relinquish the position in March 1957 owing to ill-health, but was retained by the company in a consultative capacity.

Though quiet in manner he was very hard-working, and his integrity and dependability, combined with a happy disposition, won him many friends during his long period of service in London. His chief hobby at his home in Edgware was gardening, and he specialized in the cultivation of roses and fruit.

He is survived by his widow and two daughters.

Mr. Bullen joined The Institution as a Student in 1921 and was elected a Graduate in 1923, an Associate Member in 1928 and a Member in 1935. J. R. H.

ALBERT EDMUND CLAYTON

Albert Edmund Clayton, D.SC., who was born on the 16th October 1886, died on the 13th February 1958. He was educated at Tiffin School, Kingston upon Thames, and at King's College, London, under Professor Wilson, being awarded the Solomon's Scholarship in 1905 before graduating with a B.Sc.(Eng.) honours degree.

In 1907 he joined Siemens Bros. Dynamo Works Ltd. as an assistant designer and after two years with the company became a lecturer in electrical engineering with Leicester Education Committee. This was followed by three years in the Royal Engineers during the 1914–18 War.

In 1919 he was appointed lecturer in electrical engineering at the Manchester College of Technology under Professor Miles Walker. In 1923 he was awarded the D.Sc.(Eng.) degree of London University for work on machine design and harmonic analysis of waveform, and on Professor Miles Walker's retirement he was in full charge of the heavy electrical engineering work in the department. Clayton was an outstanding teacher and endeared himself to his students and his colleagues by his genial and placid manner. He was a man to whom one could always look for help in all sorts of problems and was a great worker. He took a considerable part in the social life of the college and was Chairman of the College Refectory Committee and of the Senior Common Room. In 1946 his health broke down seriously, and he had to give up teaching before reaching the normal retiring age. During retirement he carried on his association with technical education by writing and as an external examiner for London University; he also continued to act as consultant to several firms in the electrical-engineering industry.

Dr. Clayton was author of several well-known publications on elementary electrical engineering, alternating currents, electrical machine performance and design, and power-factor correction. He had several papers on these subjects published in the *Journal* of The Institution between 1914 and 1923 and was awarded a Premium in 1916 for his paper on 'The Wave-Shapes obtaining with Alternating-Current Generators Working under Steady Short-Circuit Conditions' and again in 1924 for his paper on 'A Mathematical Development of the Theory of the M.M.F. of Windings'.

His principal hobby was gardening. He is survived by a widow and two daughters.

Dr. Clayton joined The Institution as a Student in 1905 and was elected an Associate Member in 1912 and a Member in 1924.

EDWARD STANLEY FRANKLIN

Edward Stanley Franklin, who died on the 9th March 1958, was born at Croydon in 1872 and educated at Whitgift School. Although his first choice of a career was that of a surgeon, he worked for a short period with the Rodney Foundry Co., and then entered an apprenticeship course with Siemens Bros., Woolwich, attending Finsbury Technical College part-time. On the completion of the course, he took charge of the erection of generating plant at Cheltenham, Bedford and Gloucester. He drove the first electric train from Earls Court to High Street Kensington in 1899, while working for the Metropolitan District Railway Co.

About this time Sir John Wolfe Barry recommended him for the post of Chief Electrical Engineer to the Bengal–Nagpur Railway, in which position he remained from 1901 to 1913. In 1909 he visited Stothert and Pitt, Bath, to inspect some cranes being made by that firm for the Bengal–Nagpur Railway, and, as a result of this, he became Joint Managing Director of the company in 1914, from which position he resigned in 1934. He retired in 1945, but remained an active Executive Director until 1957. He was also a Director of the Bath Gas Co., 1928–49.

Mr. Franklin had a sound judgment of both men and business, and, although he shunned publicity, he had the rare ability to get on with men in all ranks. His passing will be mourned, not only by his colleagues and friends, but by all who had the pleasure of working under and with him.

In his early life he had been a keen sportsman and was an expert polo player and rifle shot in India; in his later life he turned his attention to bowls. Although a keen gardener and craftsman, he was greatly handicapped in old age by arthritis. His chrysanthemums were always outstanding, and he spent many happy hours in his workshop. He is survived by his widow and a son.

Mr. Franklin joined The Institution as a Student in 1892 and was elected an Associate in 1895 and a Member in 1901. He was also a Member of The Institution of Mechanical Engineers.

J. G. W.

ARTHUR GIBBS

Arthur Gibbs, who died at Bournemouth on the 15th February 1958, was born in Dunedin, New Zealand, in 1877. He attended lectures at Otago University and obtained a number of diplomas. From that point he was practically self-educated, coming through the hard school in which he studied, taught and worked concurrently: that was his practice all through life.

Mr. Gibbs joined the New Zealand Post and Telegraph Department at Dunedin in 1896 and in 1912 was appointed Staff Engineer in the General Post Office at Wellington. In 1916 he was placed in charge of the department's engineering work in the Otago district and in 1917 moved to a similar position in Auckland. In 1920 he returned to the General Post Office as Assistant Chief Engineer and in 1926 succeeded to the position of Chief Engineer, which he held until his retirement in March 1932.

When radio broadcasting was in its infancy, he played a prominent part in forming the regulations covering it in New Zealand. In 1920 he visited the Polynesian Islands to prepare a scheme for linking up, by radio communication, the principal islands with Samoa, Rarotonga and New Zealand. In 1927 he represented his country at the International Radio-Telegraph Convention at Washington. In 1932 he was appointed a member of the Broadcast Coverage Commission to advise the Government on the best means of providing suitable broadcast coverage over the whole Dominion. For several years prior to his retirement Mr. Gibbs was Chairman of the Radio Research Committee of the Department of Scientific and Industrial Research. He visited the United Kingdom and Europe, where he investigated recent technical developments in the field of electrical communication. His comprehensive report to the New Zealand Government formed the pattern of future developments in communication in the country.

After his retirement he moved with his wife to the United Kingdom, but they made two holiday visits back to the country of his birth. During World War II he served as District Warden in the City of Leeds and conducted a radio engineering class for Canadian Service officers.

Mr. Gibbs was a man of sterling quality and upright character, with a winning smile and quiet insistence. Setting a high standard of conduct in both public and private life, he proved a source of inspiration to many who had the good fortune to work with him. Living a busy official life, he yet found time to assist with the work of his church and the Boys' Brigade. He was also an active member of the Philosophical Society of New Zealand. Throughout his career he displayed and maintained an enthusiasm for work that proved contagious. He became a highly respected, friendly guide and counsellor to many. He was indeed a gentleman by nature.

His name will go down in the history of the New Zealand Post Office as one of its ablest, most distinguished and respected engineers.

He is survived by his widow and a daughter, Dr. Helena Bullough of Kenley, Surrey.

Mr. Gibbs joined The Institution as an Associate Member in 1911 and was elected a Member in 1921. From 1926 to 1932 he served as Local Honorary Secretary of the Council for New Zealand. G. R. M.

ROBERT WALTER GRUBB

Robert Walter Grubb, M.A., who was born on the 22nd March 1876, died at Dewsbury, Yorks., on the 13th January 1958. A native of Oxford and a freeman of that city, he was educated at Oxford High School and at the University, where he proved himself a good athlete, representing St. Catherine's Society at rugger and rowing; he also played a fine game of tennis and was a strong swimmer.

After taking a degree in classics, he became a premium pupil with the Electric Construction Co., Wolverhampton, and he studied electrical engineering part-time at the Wolverhampton and Birmingham Technical Institutes. In 1900 he joined the British and Continental Electricity Co., San Remo, as a Shift Engineer, but the next year he returned to England to a post with the Eastbourne Corporation; two years later he was appointed Chief Assistant Electrical Engineer to the Swindon Corporation.

In 1910 Mr. Grubb became Chief Assistant to the Borough Electrical Engineer and Manager for the Dewsbury Corporation, whom he succeeded in 1918. He continued in this position until he retired in 1941. Under his guidance this undertaking grew rapidly, and he was responsible for the change of system from direct to alternating current and for the eventual closing down of local generation in favour of a supply in bulk from the nearby Yorkshire Power Co. generating station at Thornhill. He was also a pioneer in advocating assisted wiring and simple hire schemes, and by these means he brought the benefits of electricity to thousands of people in Dewsbury.

Walter Grubb was essentially a gentleman in the true sense of that word—kindly, modest and courteous. He shunned the limelight, yet in his quiet way served his day and generation and was loved by those who knew him well. His main interests were his family, his long association with St. John's Lodge of freemasons, and his membership of the Dewsbury Rotary Club. His abiding pleasures in his later life were a full pipe of tobacco, a good game of bridge, watching county cricket, and listening to classical music. He is survived by his widow and two daughters.

Mr. Grubb joined The Institution as an Associate Member in 1903 and was elected a Member in 1921. He served on the North Midland Centre Committee from 1926 to 1929. C. B.

PERCY BURNETT HALL

Percy Burnett Hall, who was the son of the Rev. Enoch Hall, died on the 12th December 1957. He was educated at Flood's Academy, Belfast, and Manchester Technical College, receiving his early practical training with Clark Chapman and Co. and the Sunderland Forge and Engineering Co.

In 1897 he joined the Adelphi Works of the General Electric Co., when Mr. Eckstein was Manager, as a switchgear designer, and later he became Assistant Manager of the Switchgear Department.

In 1905, when Mr. Eckstein and Mr. A. C. Heap formed Eckstein Heap and Co., Percy Hall joined them, and from 1905 to 1913 he was Manager of the Accessories Department in Manchester. When Eckstein Heap was made a private limited company, he was appointed a Director and Sales Manager. A few years later he became Assistant Managing Director, which position he held until he resigned in 1933 to set up in business in Manchester as an agent for Elliott Brothers, the Arctic Fuse Co. and Newton Brothers. He finally retired at the end of 1956, the business being carried on by his younger son.

He was a great family man, his whole life being wrapped up in his wife, two sons and a daughter. He followed his father's instincts in active church work and for some years played the organ. During the First World War he was active at night in the Kersal area as a special constable for the Salford police. The usual hobbies of golf, football, tennis, etc., had no interest for him, but when he started motoring he found great pleasure in driving and was, in fact, driving his car up to the week of his death. For a few years after the war he used to charter a large motor-cruiser and have two weeks away from all worries on the Norfolk Broads.

His death at the age of 80 saw the passing of one who took a very active part in the commercial development of electrical engineering in the Manchester area, particularly in the period between the two wars.

Mr. Hall joined The Institution as an Associate in 1902 and was elected an Associate Member in 1907 and a Member in 1927. A. B. M.

SIDNEY BERTRAM HASLAM

Sidney Bertram Haslam, O.B.E., who was born in Derby on the 16th December 1880, died at his home at Sandstone, Surrey, on the 5th March 1958. He was educated at Shrewsbury School and at Faraday House, gaining practical experience on the Taff Vale Railway and with Siemens Bros., Woolwich.

On leaving Faraday House, in 1904, he joined G. Harland Bowden and Co. as their South Wales Sales Manager. In 1906 he started his own business and was later joined by the late Theodore Stretton to form Haslam and Stretton Ltd., electrical contractors and agents, Cardiff, representing A. Reyrolle and Co. and other well-known firms. They designed and manufactured the Thor miner's lamp, which was used with great success in the hazardous mines of South Wales.

Mr. Haslam joined the Colours, relinquishing the position of Secretary of the Western Centre, to render distinguished service from 1914 to 1919; he served oversea and attained the rank of Major in the Royal Engineers.

On return to civilian life he continued to be active in the Western Centre and after attaining the chair in 1929–30, he worked assiduously as Hon. Assistant Secretary for the South Wales area. He was considered a tower of strength on all social occasions, particularly the Western Centre's Annual Summer Meeting and other annual functions. Mr. Haslam also had a distinguished record of service with other Institutions: he was a Member of The Institution of Mechanical Engineers, a Branch and National President of the Association of Mining, Electrical and Mechanical Engineers, and a President of the South Wales Institute of Engineers.

In private life Mr. Haslam was particularly well known for his interest in golf and had been honoured by election as President of the Welsh Golf Union and Captain of the Glamorgan County Golf Team on more than one occasion. Not only did he play the game to single-figure handicap, but he also proved himself an able administrator in the councils of the game as far as Wales was concerned. His years of retirement were spent with his wife in Surrey, this choice being made so that could be close to his son and daughter.

Sidney Haslam joined The Institution as a Student in 1904 and was elected an Associate Member in 1906 and a Member in 1911. He was appointed an Officer of the Order of the British Empire in 1945. J. V. H.

WILLIAM HAWTHORNE

William Hawthorne, B.A., B.E., was a son of the manse, being born on 1st August 1878 in Kircubbin, Co. Down, where his father, the Rev. Samuel Hawthorne, was Presbyterian Minister. He attended the Upper Sullivan School, Holywood, from which he matriculated in the Royal University of Ireland, entering Queen's College, Belfast, in 1898. He took honours degrees in both arts and engineering and won several scholarships and exhibitions. He undertook a certain amount of lecturing, and one of his pupils was Mr. Eamon De Valera.

After a short time on road work under the County Surveyor of Down, he joined the firm of Merz and McLellan, Consulting

Engineers, Newcastle upon Tyne, at the end of 1903. He served the firm continuously until his retirement fifty-three years later, particularly on railway electrification and transmission lines and, later, hydro-electric schemes. He was one of the first people to take a scientific interest in transmission lines, contributing a paper on the subject to the *Philosophical Magazine*. Hawthorne was concerned with the electrification of the Tyneside lines, which was the first scheme in this country undertaken by one of the main railways. Subsequently he assisted Mr. Merz with the first report on the Melbourne Suburban Electrification and later had the principal co-ordinating responsibility under Colonel McLellan for the Central Argentine and Buenos Ayres Western Electrifications.

During the First World War he was occupied in ensuring the supply of equipment to the Army workshops in France and in the design and construction of narrow-gauge petrol-electric locomotives, a prototype petrol-electric tank and a number of mobile power stations mounted on standard-gauge railway trucks. In 1917 he was transferred to London to facilitate the war work on which he was engaged and spent some time at Light Railway Headquarters in France during 1918. After the war he assisted Mr. Merz on the electrification of the South African Railways between Glencoe and Pietermaritzburg and the Cape Town suburban system. After this he acted as Colonel McLellan's right-hand man in all the planning and preliminary work which led to the formation of the Galloway Water Power Co. and subsequently in the carrying out of the Galloway power scheme. He and his colleague, Mr. F. H. Williams, were awarded the Cooper's Hill Memorial Prize for a paper to The Institution of Civil Engineers on the 'Mechanical and Electrical Equipment of the Galloway Hydro-Electric Development'. Apart from visits to the railway electrification schemes with which he was associated in South Africa and the Argentine, Hawthorne travelled widely on the firm's business, visiting many Continental countries and also Brazil. He had many extra-mural activities. In his college days he was Secretary of the Students' Union and President of the Literary and Philosophical Society. Later he was Honorary Secretary and subsequently Trustee of the Queen's University Club, London, and represented the Vice-Chancellor on the Universities' China Committee in London. He was a keen Rotarian, being a member of the Rotary Club of Esher of which he was Vice-President in 1952–53.

As a boy he was fond of sailing on Strangford Lough and later was active in swimming, gymnastics, fencing, walking and rowing. Accompanied by his great friend and colleague, Mr. R. W. Gregory, he tramped the moors and fells of the North and South Tyne and spent many summer holidays on foot visiting the less frequented parts of Norway, the Pyrenees, Corsica and Serbia. He was a delightful companion, full of whimsical humour and with a wide knowledge of things in general. His colleagues both respected and loved him, and he was always ready to give them a helping hand.

In 1912 he married Elizabeth Curle Greenfield, who at the time of her marriage was Senior Mistress at Morpeth High School. She died in 1952. There are three sons of the marriage, all of whom have achieved distinction in their respective activities.

Mr. Hawthorne joined The Institution as a Member in 1938. He was also a Member of The Institution of Civil Engineers, and in 1938 was elected a member of the Société des Ingénieurs Civils de France, of the British Section of which he became President in 1949.

J. R. B.

RALPH GILSON HIGHAM

Ralph Gilson Higham, J.P., who died on the 18th August 1957, was born on the 15th May 1888. He was educated at Oundle School, and studied part-time at Armstrong College, Newcastle upon Tyne, while an apprentice with Palmer's Shipbuilding and Iron Co., Jarrow. On the completion of his apprenticeship in 1910 he stayed with the firm for a short time before joining Messrs. Drake and Gorham, Manchester, in 1911, with whom he was subsequently appointed Assistant Chief Engineer.

In 1914 Mr. Higham became Manager of the Electrical Department with Greaves Cotton and Co., Bombay, and in 1916 joined the Electrical Department of the Bombay Government as Assistant Electrical Engineer. He was promoted to Executive Engineer, Public Works Department, and in 1936 became Electrical Engineer of the department. He retired from the Bombay Government service in 1946.

During his period of service with the Bombay Government, the Public Works Department expanded in various fields, and, owing to his personal efforts, the department was made permanent. He was also mainly responsible for enforcing the Bombay Lifts Act in the State of Bombay and organized the Licensing Board on a sound footing. The inspection of electrical installations in the city, as well as outside in the State, was reorganized so as to extend adequate service to the public, and the department was thus made self-reliant. By his gentle and courteous disposition, he endeared himself to all with whom he came in contact, including the large staff working under him.

He was a member of the Bombay Yacht Club and took a very keen interest in its activities. He was Secretary and, later on, President of the Rotary Club for some time.

Mr. Higham joined The Institution as a Graduate in 1918 and was elected an Associate Member in 1919 and a Member in 1922. He served on the Bombay Local Committee 1932–36 and thereafter became Chairman, which appointment he relinquished on retiring from Government service in 1946, when he returned to the United Kingdom. He is survived by his widow.

T. M. S.

CHARLES GEORGE MORLEY NEW

Charles George Morley New, C.B.E., who died on the 10th December 1957, was born at Cardiff on the 24th July 1879. After leaving Cardiff High School he served an apprenticeship with S. F. Walker and Co., Cardiff, from 1894 to 1899, and obtained his technical education by private study and at the Yorkshire College, Leeds. He then became a pupil in the Leeds Corporation Electricity Department, and in 1901 he was engaged as an assistant shift engineer and testing assistant. In 1902 he returned to his home town as a shift engineer at the Eldon Road generating station.

At Cardiff Mr. New had a long and distinguished career, serving in various capacities; he was appointed Deputy Electrical Engineer (Lighting and Tramways) in 1907 and became City Electrical Engineer and Manager in 1920. His untiring energy and sound administration were instrumental in the rapid development of the undertaking; between 1920 and 1935 the number of consumers increased from 5200 to 49000, and the energy generated annually increased fivefold.

In 1935 Mr. New was appointed an Electricity Commissioner, and when the Commission was dissolved in 1948 he was its Deputy Chairman. He then served as a part-time member of the South Eastern Electricity Board until his retirement in 1955.

He gave evening lectures on electric lighting and power transmission at the Technical School, Cardiff, and he was President of the College Engineering Society in 1933–34. He was also the first Local Examiner in South Wales, in 1911, for the examinations instituted by the Association of Mining Electrical Engineers.

Mr. New had many interests complementary to his official duties, among them being his membership of the South Wales Institute of Engineers, in which he served as a Member of Council; in later years he was invited to give the William Menelaus Memorial Lecture of the Institute, taking for his subject 'Public Supply of Electricity in Great Britain—its Development and Services to the Community'. He was a Member of Council of the Incorporated Municipal Electrical Association from 1926 to 1935, becoming President in 1931. He gave years of valuable service to the Electrical Development Association as Chairman of the South Wales Committee and as a Member of Council; and he also served on many committees of the Electrical Research Association, and represented the Electricity Commission on the Council for thirteen years. Shortly after his retirement he was appointed a C.B.E. for his great service to the electricity supply industry.

In his early days Mr. New was a keen hockey player; later he took up golf, which he enjoyed until shortly before his last illness. He was a keen motorist and was for many years an active member of the Cardiff Rotary Club. A man of great charm, he was extremely conscientious and thorough in all his ways, and many young

engineers had cause to be grateful for the help and guidance which was so readily given. He is survived by his widow, son and daughter.

Mr. New joined The Institution as an Associate Member in 1910 and was elected a Member in 1920. He served on the Western Centre Committee from 1916 to 1936 and was Vice-Chairman from 1925 to 1927 and Chairman in 1927–28. He also served as a Member of Council from 1933 to 1936 and on the Benevolent Fund Committee from 1941 to 1944. His progress review entitled 'Domestic Applications of Electricity' was published in the *Journal* in 1930.

E. J.

ROBERT WOOD MIDDLETON

Robert Wood Middleton, who died on the 14th January 1958, was born on the 6th March 1898 in Manchester. Mr. Middleton's last illness was not a long one, and it was thought that his health was gradually improving at the time that he suddenly died.

Although he was born in Manchester, much of Mr. Middleton's life was spent in Scotland. His early education was in Glasgow, and later he attended schools in Ashington and Hirst in Northumberland. In 1912 he began an apprenticeship with Bentinck West Hartley Coal Co., Newcastle upon Tyne, which was followed by a two-year apprenticeship with Brash and Russell Ltd., Glasgow. He remained with this firm on the completion of the course and was put in charge of outside erection.

In 1923 he joined Robert M. Russell Ltd., Glasgow, as Technical Engineer and Estimator. He was lent by the company to the Sierra Leone Development Co. in 1933, and for a year he was engaged on the installation of a complete electrical plant, including switchgear, overhead lines, motors and pumping equipment, in Sierra Leone.

Returning to Britain in 1934, he spent some time with the Campbeltown and Mid-Argyll Supply Co. as Mains Engineer and with W. A. Smith and Co. as Power Technical and Commercial Engineer; in these capacities he was responsible for the preparation of heavy power schemes, including estimating, specifications and supervision of installation.

He joined Imperial Chemical Industries in 1937 as an electrical engineer at the Ardeer explosive factory of the Nobel Division of the company, rising to the position of Senior Electrical Engineer in the factory, which position he held at the time of his death. In the course of his duties he developed special forms of lighting and dustproof lighting fittings for tungsten-filament and fluorescent lamps for use in buildings in which there was an explosive hazard. He gave considerable thought to the requirements of lightning protection and anti-static flooring as preventive measures against the hazards of the industry. He served for many years on the I.C.I. Electrical Panel.

In his younger days Mr. Middleton played soccer, tennis and golf, and one of his main interests in life was the education of youths undergoing electrical training. He is survived by his widow and two married daughters.

Mr. Middleton joined The Institution as an Associate Member in 1941 and was elected a Member in 1948.

F. B. W.

WILLIAM JOHN UNWIN SOWTER

William John Unwin Sowter, who died at Bray on the 10th January 1958, was born at Margate in 1874. He was educated at Cliftonville College, Margate, and Finsbury Technical College, London. He completed a four-year apprenticeship with Ferranti Ltd. in 1893 and filled positions as Resident Engineer, Mains Engineer and Shift Engineer with various supply undertakings. In 1903 he was appointed Borough Electrical Engineer by the Dorchester Corporation and in 1904 he became Chief Electrical Engineer of the Bray undertaking in Co. Wicklow.

Unfortunately, in 1912, one of the air cylinders for a Diesel engine at Bray fractured, killing one of the engine-room staff and severely injuring Mr. Sowter. He was never again able to get around without the use of two sticks and only then with great difficulty. However, as soon as possible he returned to his duties, and the undertaking prospered and expanded. It had grown considerably when acquired by the Electricity Supply Board in 1930, and Mr. Sowter continued as Area Manager and was responsible for much development before his retirement in 1949.

The measure of a man is how he reacts to pain and misfortune. Mr. Sowter never complained, and he bore the consequences of his grievous injuries with fortitude and cheerfulness. He was ever kindly and understanding and could get the best out of his staff. He had a very high sense of the social responsibilities of an engineer and the place and position he should occupy if he were to serve effectively. In fact, service motivated him not only before his accident but for the many years that followed, and to the end he continued to give the industry all he had.

Mr. Sowter was unable to join in or follow any form of outdoor sport, and reading was his only recreation. This added to his wide experience of men and matters and made him the wise counsellor and sympathetic adviser that we who were privileged to know him valued so highly. He is survived by his widow and two sons.

Mr. Sowter joined The Institution as an Associate in 1899 and was elected an Associate Member in 1904 and a Member in 1909. He served on the Irish Centre Committee from 1929 to 1933.

R. A. H. J.

GEORGE LESLIE WATES

George Leslie Wates, J.P., who was born on the 12th July 1884, died at his home on the 22nd January 1958, after a long illness.

Mr. Wates spent his early life in Lewisham and was educated at Haberdashers' Aske's Grammar School. He qualified as a solicitor in 1905, obtaining first-class honours and being awarded the New Inn Prize. He went into practice with his cousin as a partner in the firm of Whale and Wates, which in 1920 became incorporated in Messrs. J. D. Langton and Passmore, and in this he continued as a partner until 1951, when he became a consultant to the firm.

As a young solicitor he became the close friend and associate of the late Walter Claude Johnson, one of the founders of Johnson and Phillips Ltd. He joined the Board of the company in 1927, and in 1931 was elected Chairman. He became Joint Managing Director and continued as Chairman until he relinquished the appointment in 1957 owing to ill-health; in the same year he was appointed Honorary President of the company.

Mr. Wates was appointed a Justice of the Peace for the County of London in 1928.

During the years 1908–48 he was associated with the Woolwich Memorial Hospital, of which he became a governor. He was a member of the Executive Committee of the Roffey Park Rehabilitation Centre from 1943 to 1948 and of the Roffey Park Hospital Management Committee in 1950.

In 1932 he joined the Board of the Woolwich Equitable Building Society and became Chairman in 1949, from which office he resigned in 1957. He was Chairman of the Canning Town Glass Works and a director of a number of other companies.

Mr. Wates served as a Member of the Council of the B.E.A.M.A. from 1943 to 1957, and he was Chairman in 1950–51. During his term of office as Chairman he took a prominent part in the raising of £72,000 to endow a Chair of Electrical Engineering at Cambridge University. He was Chairman of the Cable Makers' Association in 1946–47.

Mr. Wates's interests were many and widespread. He found relaxation in the pursuit of farming and horticulture. He was always deeply concerned with the welfare and progress of young people, and his keen interest in education found expression at the Woolwich Polytechnic, where he was a governor from 1939 to 1957 and Chairman of the Governing Body for three years of that period. Mr. Wates was known by all with whom he associated for his clear analytical thinking and for his integrity of purpose. He made a considerable impact upon the many circles in which he moved. He was a man of great human kindness and had a deep affection for his fellow men.

He is survived by his widow, two sons and two daughters, and fifteen grandchildren.

Mr. Wates was elected to The Institution as a Companion in 1953; he was a Member of Council from 1955 to 1958, and a member of the Finance Committee of the Court of Governors of the Benevolent Fund from 1955 to 1957.

W. G.

MONOGRAPHS AND PAPERS
published individually this month

Synopses of monographs and papers published individually before the next issue of the Journal are given below, and, unless otherwise stated, their dates of publication are this month. Reprints of all papers are available about two months after publication in the Proceedings. The prices shown below are post free. When ordering please quote serial number of paper or monograph. Books of eight vouchers may be obtained from the Secretary, price 10s. each.

	PAPER FOR READING	PAPER FOR PUBLICATION ONLY	MONOGRAPH
More than 10 days before first reading (if published early) ..	2s. 6d.[1]	—	1s. 3d. (From date of individual publication, including period after republication in the *Proceedings*)
Period of 10 days before first reading	Free[2]	—	
Period between first reading and republication in the *Proceedings*	Free if available[2]	—	
Reprints (after publication in the *Proceedings*)	1s. 3d. (includes discussion)	1s. 3d.	

[1] This charge includes a reprint of paper and discussion
[2] If a reprint of paper and discussion is also required a remittance of 1s. 3d. should be sent

MONOGRAPHS

An Exact Theory of *N*-Component Steady-State Operators for Linear Circuits *Monograph* 306 M

A. J. O. CRUICKSHANK, B.SC., PH.D.

A theory of *N*-component operators is given for steady-state calculations in linear circuits with inputs of periodic, but non-sinusoidal, form. If the input waveforms have a finite number *M* of harmonic components, *N* may be chosen such that an exact theory results. The theory supplements an approximate one of the same nature recently published. The central feature of the method is the decomposition of any periodic function with *M* harmonic components into a number of samples of the same form, but of magnitudes equal to the ordinates of the function at equal intervals τ throughout the period and displaced in the time-axis by successive intervals τ. By appropriate choice of the sampling function, an exact representation may be obtained.

A shift operator u is now introduced which translates any periodic function one interval τ to the right. By this means it is possible to express a periodic function with *M* harmonics as a production of a polynomial in u and the basic sampling function. This polynomial in u, of order $N-1$, gives an *N*-component operator representing the waveform. The representation is, in a sense, analogous to that used in vector algebra, where an arbitrary sinusoidal wave may be written as the product of a polynomial in j, such as $a+jb$, with a basic sinusoidal reference wave. The theory gives rise to the fundamental results $u^N = 1$ and $u^N = -1$ for general, and odd harmonic only, waveforms respectively, and using these, a standard form for an *N*-component operator may be obtained.

Differential and integral operators are developed, and rules are given for obtaining the *N*-component operator corresponding to an impedance, admittance or transfer function. The algebra of *N*-component operators is summarized and the solution of a simple circuit examined by way of illustration. The process of inverting an operator requires the solution of *N* simultaneous equations, and an alternative method of procedure is considered. Simple expressions result for power and r.m.s. values.

The application to linear circuits is advantageous in the case when the input is known graphically or numerically and a similar description of the output is desired. It is therefore an alternative method of procedure to Fourier analysis, calculation of the responses to the harmonic components, and subsequent point-by-point plotting of the output. The theory may also be applied to the solution of non-linear circuits by continued approximation.

The Discrimination of a Synchronized Oscillator against Interference Accompanying the Synchronizing Signal *Monograph* 307 R

R. SPENCE, B.SC.(ENG.), *and* A. R. BOOTHROYD, PH.D.

An oscillator may be synchronized by an injected signal if the frequency of the signal is close enough to the natural frequency of the oscillator and if its amplitude is sufficiently large. The output of the oscillator then contains only the frequency of the injected synchronizing signal. In practice, an interfering signal is usually present in the input to the oscillator together with the synchronizing signal, and an important property of the synchronized oscillator is its discrimination against the interfering signal even when the difference between the interfering and synchronizing frequencies is infinitesimal. The response of the oscillator to the interfering signal is investigated in conditions where the interference component of the oscillator output is small; the response is found to be linear, and the discrimination is expressed analytically. Good agreement between theory and experiment is obtained.

PAPERS

A New High-Speed Digital Technique for Computer Use *Paper* 2672 M: *Part B*

D. ELDRIDGE, B.A.

A new method is described for realizing logical functions using square-loop ferrite cores and transistors. Complex circuits can be built up from identical elements, each consisting of one core, one transistor, three diodes and one resistor. The technique differs from earlier methods in that the current required to set a core to the '1' state is derived from a common supply and not from a previous stage.

The control of digit transfer between stages is effected by a transistor whose collector and emitter are connected across one winding of the core. When a '1' is to be set in the core, the transistor is arranged to appear as an open-circuit, in which

condition flux reversal is possible; when a '0' is to be set, the transistor appears as a short-circuit preventing reversal of flux.

The core is reset to '0' at a controlled rate, producing a standardized voltage across the output windings. Logical operations are carried out by the analogue addition of these voltages. The system requires only two low-voltage d.c. supplies and is tolerant of voltage and component variations. It operates reliably at digit rates of 500 kc/s.

Rating of Speech Links and Performance of Telephone Networks
Paper 2666 R: *Part B*

I. SWAFFIELD, PH.D., B.SC.(ENG.), *and* D. L. RICHARDS

A serious problem which occurs in the development of large or otherwise costly speech-communication systems (the term includes, but is not confined to, public telephone systems) is the achievement of a consistent overall design that is economical and yet never requires users to exert unreasonable amounts of mental or vocal effort in conducting their conversations. The ideal thus simply expressed is notoriously difficult to achieve, and the problem is of long standing in the history of telephony. The paper reconsiders this problem and sets out a coherent 'design' procedure by which studies of *rating* (providing figures of merit in terms that are meaningful for engineering-design purposes) and *user evaluation* (study of merits of speech links for particular applications) can be conducted to yield closely complementary information.

These two aspects, 'rating' and 'user evaluation', are concerned respectively with individual speech links and with systems or networks viewed as aggregates of such links. A further type of study, also important, deals with estimating the grade of performance which a complete network, designed to a given transmission plan, will provide; this can be described in statistical terms such as the proportion of calls of various types whose transmission should yield various levels of satisfactoriness to users. This last type of study, conveniently known as 'network-transmission performance', is of special value in the long-term planning and operation of large systems.

The Acoustic Design of Talks Studios and Listening Rooms
Paper 2676 R: *Part B*

C. L. S. GILFORD, M.SC.

The paper gives current B.B.C. views on the design and construction of talks studios and listening rooms or control cubicles, which are considered together on account of their similarity with respect to acoustic behaviour. Because their dimensions are comparable with the wavelength of low-frequency sound, the sound field is characterized by strong simple standing-wave patterns which cannot be eliminated without eliminating the reverberation itself. The audible effects are confined to those associated with simple axial modes, and by careful adjustment of dimensions, provision of diffusion and the proper distribution of absorbing material, the worst faults can be avoided. The effects of the monaural listening chain are considered, as well as the consequent necessity for reduced background noise and reverberation in studios as compared with a normal living-room.

Finally, design data for both talks studios and control or listening cubicles are given.

TECHNICAL PUBLICATIONS

E.R.A. REPORTS

Copies of the undermentioned E.R.A. Reports can be obtained from the British Electrical and Allied Industries Research Association, Thorncroft Manor, Dorking Road, Leatherhead, Surrey.

D/T101 **Flameproof Electrical Apparatus: Flanged Joints, One Half-Inch in Radial Breadth, in Mixtures of 1 : 3-Butadiene and Air** by T. J. A. Brown and N. Simpson. 7s. 6D.

The determination of the safe gaps for butadiene/air mixtures ignited in a vessel with a flange breadth of 1 in. has been previously described in Report G/T233. The effect of halving the flange breadth is to reduce the maximum experimental safe gap by 18% and the statistical maximum safe gap (re-assessed) by 12%.

D/T103 **The Effect of Acid-Etching on Well-Glasses for Flameproof Lighting Fittings** by H. G. Riddlestone. 6s.

The British Standard for flameproof electric lighting fittings, B.S. 889, prohibits etching or other methods of roughening the surfaces of well-glasses for use with these fittings. This is because of the possibility of serious deterioration in the strength of the toughened glass of which the well-glasses are made if the outer fire finish is damaged. To overcome the problem of 'glare' from clear-glass fittings, however, it has been suggested that acid-etching to a small depth could be allowed, with no reduction in safety, but with sufficient diffusion to alleviate the problem. This report describes tests made to determine the effect of the etching on the strength of the well-glasses.

D/T105 **The Effect of Circuit Resistance on the Discharge Energy Required for the Ignition of Methane-Air Mixtures** by H. G. Riddlestone. 7s. 6D.

This report describes the continuation of investigations on the ignition of an 8·3% methane/air gas mixture by capacitive discharges in circuits of variable resistance. In a previous report, G/T304, the effect of series resistance on the critical stored capacitive energy required to ignite the gas mixture was described. The actual discharge energy has now been measured for the same critical circuit conditions, using the method of measurement previously described in Report G/T293, with values of circuit resistance up to 25000 ohms.

G/XT85 **Performance and Post Arc Resistance of E.R.A. Side Blast Baffle Circuit Breaker in Heavy Current Tests** by W. B. Whitney and L. Gosland. 21s.

This report gives particulars of some tests on an E.R.A. side-blast baffle switch.

Results indicate that, with available design data, uniform operation of a baffle switch over a wide range of currents is attainable, which should make possible a reduction in depth

of baffle pot as compared with other designs less uniform in operation. At the upper end of the current range the tests were mainly made to examine the suitability of a baffle switch for use as a β-switch in the study of restriking voltage transients for power-supply networks. Results show that such a switch is suitable over a wide range of working conditions. Certain limitations are discussed, and methods of minimizing them are suggested.

L/T263 Effect of the Cathode Material on the Breakdown Strength of Amorphous Dielectrics by J. J. O'Dwyer. 6s.

The intrinsic breakdown strength of amorphous dielectrics has been calculated by Fröhlich on the basis of a fairly general model of an amorphous dielectric. Using the same model, it has been shown in Reports L/T178 and L/T220 that the intrinsic breakdown time should be less than 10^{-10} sec for almost all substances of this type. The purpose of the present investigation is to interpret breakdown experiments in the light of the above theory with particular reference to the cathode material.

L/T326 The Electrical Properties of Tungsten Trioxide (Interim Report) by J. Hirsch. 24s.

In this report the electrical properties of tungsten trioxide ceramic capacitors, and the dependence of their properties on temperature and chemical treatment, have been assessed in terms of the Maxwell–Wagner model of a non-uniform dielectric. On the basis of the results obtained, some conclusions are drawn concerning the use of the material as a high-permittivity dielectric.

L/T330 The Concentration of Current at Arc Cathodes by A. E. Robson. 7s. 6D.

The discussion refers to all cold-cathode arcs, that is to say arcs whose cathode materials have boiling points far below the temperatures at which thermionic emission could occur.

The mercury arc is characterized by a small bright spot at the cathode which is constantly in random motion over the cathode surface. This 'spot' is actually a luminous region of dense excited and ionized vapour immediately above the current-carrying area of the cathode. On account of its small size and random motion, only a few measurements have been made on the properties of the spot, and these, together with observations, have permitted an assessment of conditions in the spot region.

L/T331 The Electron Emission at the Cathode of a Cold Arc by A. E. Robson. 6s.

The mechanism by which electrons are emitted from the cathode of a 'cold' arc has been the subject of a number of theories. The arc with a refractory cathode is quite well understood in terms of thermionic emission, but if the cathode material boils at temperatures well below emitting temperatures, thermionic emission is clearly out of the question and some other process must be considered. In the paper the authors refer to an arc with a liquid mercury cathode, but the remarks apply to all non-thermionic arcs.

A mercury arc can be run with a potential of only 10 volts between anode and cathode: the cathode fall in potential must therefore be rather less than 10 volts. Consequently, if the total arc current is 1 amp, the energy liberated in the discharge is about 10 watts. Assuming that nearly all the current at the cathode is carried by electrons and that the work function of the cathode is 4·5 volts, approximately 4 watts out of the available 10 watts must be used in releasing electrons from the cathode. Thus not only must at least half the discharge energy be fed back to the cathode, but an electron emission process of nearly 100% efficiency must take place there.

The cathode fall of a thermionic arc is also low (15–20 volts). In this case the energy is fed back to the cathode by positive ions, and once the cathode has reached emitting temperature, the emission efficiency is very high. This is because the process by which energy is usually lost, i.e. heat, is used to emit electrons.

L/T349 The Emission of Ionizing Radiation during a Spark Discharge by W. A. Prowse and G. R. Bainbridge. 12s. 6D.

A high-voltage pulse lasting 0·35 microsec is applied to two delay lines, so that two pulses can be picked up from adjustable points of connection on the lines. One is applied to an irradiating gap and the other to a longer gap, the gaps being so arranged that only mid-gap irradiation takes place. The sparking probability P of the test gap is used to indicate the presence of ionizing radiation. Variations of P with the time interval between the two pulses are recorded. They indicate that ionizing radiation is emitted in repeated short flashes. Photographic observations support this view. Some measurements of the absorption coefficients of the ionizing radiation are recorded.

L/T355 The Dielectric Properties of Nylon by E. Rushton and G. Russell. 10s. 6D.

The dielectric properties of a pure nylon and also of nylon containing 0·3% titanium-dioxide filler have been investigated over a range of frequency from 60 c/s to 36×10^9 c/s and over a temperature range of -80 to $+170$° C. It is found that the addition of the filler has practically no effect on the dielectric behaviour. Absorption of water increases the dielectric losses, but in the dried condition the material has a permittivity (ϵ) of between 3·8 (at low frequency) and 3·0 (in the microwave region), and the loss tangent ($\tan\delta$) lies between 0·01 and 0·025 depending on the frequency. The behaviour of the nylon is of a complex character, due presumably to the number of different polar groups in the molecule, and the results suggest that several loss mechanisms are at work. One process gives rise to absorption effects at room and low temperatures and another to larger effects at temperatures of about 100° C. At higher temperatures (130° C and upwards), the conductivity of the material becomes relatively high, values of ϵ as high as 40 and $\tan\delta$ of up to 1·5 being observed at the lower frequencies.

T/T52 An Investigation into the Laws Relating to the Rate of Wear and Change of Friction with the Number of Revolutions Performed in Meter Type Bearings by G. F. Shotter and G. F. Tagg. 12s. 6D.

In connection with the researches carried out on various jewel and pivot combinations, an examination of the friction-life curves given in Reports T/T39 and T/T48 suggests that there is a definite law connecting the increase in friction with the total number of revolutions. The general shape of all the curves is the same—an initial increase, a flattening out of the curve, and then a final rise before the increase has reached the limiting value. In this report an empirical law connecting the increase in friction with the number of revolutions has been established, and an approximate theoretical law has been deduced.

SOME RECENT BOOKS

R. HANBURY BROWN AND A. C. B. LOVELL
THE EXPLORATION OF SPACE BY RADIO

CHAPMAN AND HALL. 1957. 207 PP. 35S.

Radio astronomy has become widely known in recent months through the applications of its techniques to the tracking of the Sputniks. A new book describing the methods used in astronomy at radio wavelengths and the results obtained is therefore particularly welcome. The development of radio astronomy over the last ten years has been so rapid that it no longer seems possible to write an advanced work covering the whole subject, and the authors have decided that there is a need for an elementary textbook. But this is by no means a book for the layman. The reader needs a good grounding in science, particularly for the first third of the book, dealing with the receivers and aerial systems used in the observations, and it will be of most interest to those with technical knowledge of some other branch of radio or astronomy.

After a general introduction to the astronomical side, the authors cover all the different branches of radio astronomy, such as the solar radio emission, galactic and extragalactic radio sources, the scintillation or twinkling of radio sources, and radar echoes from meteors, aurorae and the moon. In some respects the emphasis seems misplaced. For instance, to devote as much space to the scintillation of radio sources as to the observations made of the 21 cm spectrum line of hydrogen seems more than remarkable. This spectrum line, the only one in radio astronomy so far discovered with certainty, provides the only known method for measuring the distances of radio sources and has most fundamental application in deducing the structure of our own and other galaxies.

The book is freely illustrated, and the diagrams are clear. A wider range of photographs of radio telescopes would perhaps have been of more general interest than the many details shown of the Jodrell Bank telescope. Apart from the mistake in Fig. 33, which is too apparent to mislead, there are very few errors of fact. This book, by two leading workers in the field, is a most welcome addition to the small number of books on radio astronomy.

H. J. GRAY (*Compiler and Editor*)
DICTIONARY OF PHYSICS

LONGMANS, GREEN. 1958. 544 PP. £4 4S.

What does one look for in a dictionary? An exhaustive coverage of the subject, precise definitions of the terms and adequate cross-references. This monumental work has all these virtues and many more besides, for it approaches the scholarship of an encyclopedia. Compiled by Mr. H. J. Gray, with contributions from an impressive team of scientists, the dictionary achieves a high standard. The entries are not merely definitions but essays, succinct and authoritative, long enough to be easily readable but not cluttered with unnecessary information. Two praiseworthy features are the addition, in the main articles, of references to relevant papers and books, and the inclusion of biographical articles on the pioneers of physics. Also noteworthy is the complete description given of each chemical element, including the stability and relative abundance of its isotopes.

A dictionary of physics would not be expected to cover electrical engineering, except where the two subjects overlap. Yet this book does provide a surprisingly extensive coverage of electrical engineering terms—and not all of them are on the light-current side. Typical examples picked at random are: surges, feedback, generators, maximum demand, transistors, transductors, transducers, diversity systems, and the star-delta switching starter. Indeed, the reviewer found it hard to catch the dictionary out, although it did fall down on the digital computer. It was clearly even harder to find omissions in the realm of pure physics.

Nevertheless the dictionary possesses a serious flaw in its undeniable lack of balance between classical and modern physics. Thus, for example, while nearly four columns are devoted to optical interference, the theory of relativity is dealt with in a paragraph; while Kundt's tube receives a whole page, nuclear magnetic resonance is dismissed in a couple of sentences.

The diagrams are very good, being for the most part neat, clear and functional, and although they are used intelligently and conservatively they total 450. Unfortunately, the diagrams show the same bias towards elementary physics as the entries themselves. For example, the drawing of the Dolezalek electrometer seems to have been reproduced from a sales catalogue and fills over half a page, quite unnecessarily, while on the other hand the illustration of the Wilson cloud chamber is totally inadequate. Also, the simple article on the hydraulic press is graced with two diagrams; that on the mass spectrometer with none.

The editor has not followed the recommendations of the British Standards Institution regarding units, symbols and abbreviations, and in several of the formulae quoted he has forgotten to define the symbols used. If the articles on basic physical quantities had included both the symbol and the various units in which the quantity is measured, the book would have been greatly improved.

The book is well printed on good paper and is stoutly and not unattractively bound, although at the rather high price of four guineas this is to be expected.

Owing to its bias towards elementary physics, the dictionary is to be commended to schools and colleges rather than research laboratories, though it would not be redundant in the latter. For most electrical engineers the book is probably too physical, but the research engineer may find it useful.

L. E. C. HUGHES (*Editor*)
ELECTRONIC ENGINEER'S REFERENCE BOOK

HEYWOOD. 1958. 1303 PP. £4 4S.

During recent years electronic engineering in some form or another has penetrated almost every branch of engineering activity. The *Electronic Engineers' Reference Book*, edited by Dr. Hughes, is therefore a particularly welcome addition to the literature available. The work will be of greatest value to the qualified engineer in any branch of industry who wishes to assess effectively and quickly the potentialities of electronic solutions to his problems. Electronic engineering as a whole has become so wide, however, that a specialist in one branch of the subject may soon be out of his depth in a neighbouring branch, and as the range covered by this book is so vast (for example, from astronomy to acoustics) it is to be expected

that it will appear also on the bookshelves of a large percentage of electronic engineers. Apart from its use as a reference book, its possession kindles an urge to study the unfamiliar subject, since the presentation of the various sections is generally such as to promote a basic understanding quickly. The book will therefore add a contribution to the general widening in the outlook of engineers.

The book is divided into nine main subject headings, with further subdivision into separate specialist categories. Each of these specialist sections is the work of an expert, and the information given seems in all cases to be right up to date. The way in which liberal references are given directly alongside the particular aspect of the subject is much to be appreciated.

It is inevitable that a book covering such a wide field will be rather large, and one wonders whether its bulk could be reduced by the use of thinner paper. Still looking for means of reducing the bulk one might question the wisdom of including in the work mathematical tables and a number of tables on mechanical matters such as pipe threads, screw threads and copper-wire data, since most engineers will have such information in other books.

One of the first needs of an engineer faced with an electronic problem is to get some appreciation of the fundamental characteristics of the various components and devices involved, and this reference book enables him to do this with notably few exceptions. Considering the increasing industrial use of television, some short descriptions of television camera tubes and their characteristics would have been useful. References to the principles underlying colour-television tubes might also have been of more value to the general engineer than the detail of the N.T.S.C. colour system, which was devised for the rather special requirements of broadcast colour television.

In many sections of the book (e.g. acoustics) there is extremely useful information on measurement and measuring apparatus, but there is no definite section of the book dealing with the measuring tools of electronics generally. To cover this field adequately would add to the bulk of the book, and the statement in the preface that reasons of space have forced certain exclusions must be accepted.

These small comments must be understood to be the result of trying hard to find grounds for criticism in an excellent and useful reference work.

A. W. KEEN
FREQUENCY MODULATION—AN INTRODUCTION TO THE FUNDAMENTAL PRINCIPLES

PITMAN. 1958. 274 PP. 30S.

The author, who is Senior Lecturer in Electronics and Telecommunications at Coventry Technical College, has divided his book into six chapters and two appendices. Chapter 1 deals with the frequency-modulated signal, using the minimum amount of mathematics but describing the three forms of modulation—amplitude, phase and frequency—with the aid of vector diagrams which give a very clear understanding of the subject. The second chapter describes the various methods of generating f.m. signals, which now include cathode-ray-tube phase modulators, the phasitron tube and f.m. klystrons. The next chapter is one of the longest and gives a considerably more detailed discussion of f.m. detectors than is to be found in most high-priced textbooks. Interference and distortion are dealt with in Chapter 4, and here the author might usefully have included a little more numerical information. Transmitters and receiving equipments are described in Chapters 5 and 6, and the author has illustrated the various receiver techniques with an adequate number of current receiver circuit-diagrams. The two appendices contain a brief account of the mathematics of frequency modulation and a large number of selected references to the various aspects of the subject.

For the student and engineer, as opposed to the purist, this book can be unhesitatingly recommended as among the best on the subject. A slight criticism is that the publishers might have had it printed on better paper, even if this meant adding a shilling or two to the retail price of the book.

J. MOIR
HIGH QUALITY SOUND REPRODUCTION

CHAPMAN AND HALL. 1958. 591 PP. £3 10S.

Mr. Moir, who has become well known as an authority on what is popularly termed 'Hi-Fi', has now produced this book for the benefit of the professional engineer and the knowledgeable amateur. Although he remains an amateur himself in the best sense, with all the amateur's enthusiasm, Mr. Moir's knowledge is backed by his professional engagement in acoustical problems and the design of sound-reproducing systems. For this reason his book will be received with interest and respect.

It is a big book and covers a wide field, treating in a useful and practical way the more difficult aspects of the subject which are so often by-passed elsewhere. The text is mainly non-mathematical, but readers are expected to have some knowledge of electronics. To those so equipped, it provides an admirable introduction to the intriguing and tantalizing problems associated with sound reproduction. The book has a personal flavour and reflects, in the main, the author's particular outlook and interests; but it is none the worse for that, particularly as most of what is set down is from first-hand knowledge and experience.

There are nineteen chapters, the first three serving as a general introduction to sounds and their subjective appreciation. A fourth chapter on realistic performance specifications is then followed by chapters on microphones, mixers, gramophones, magnetic recording, voltage and power amplifiers, transformers, feedback, tone control, rectifiers, dividing networks, loudspeakers, acoustics, cinema and stereophonic sound reproduction. One appendix gives definitions of acoustical terms, and another enlarges on the nature of the decibel.

Despite its length, the book does not attempt to give sufficient detail to be of much use to the specialist. Instead, references to published papers are given at the end of each chapter for the benefit of those who might wish to follow any particular line more closely.

There is a tendency throughout the book to concentrate on bulky expensive apparatus. To many readers, however, questions of cost, size and weight are still quite relevant when dealing with something so essentially subjective as 'high-quality sound'.

One rather surprising omission is any reference to the problems of radio receivers (including television sound) which start at the detector and not the amplifier. Surely, after all that the B.B.C. has done to provide us with high-quality transmissions, some consideration might have been given to this topic?

It would, however, be impossible to please everybody, and Mr. Moir is to be congratulated in so clearly presenting

a wealth of information, even if it is, at times, a little provoking.

The book is very nicely printed and well illustrated.

F. LLEWELLYN-JONES

IONISATION AND BREAKDOWN IN GASES

METHUEN. 1957. 176 PP. 18S.

The publication of this book by a well-known authority on the subject of discharges in gases will attract the notice of very many electrical engineers and physicists, since the characteristics of the discharges are now important in applications covering an enormous range of gas pressures, discharge length, current, and materials.

Professor Llewellyn-Jones has aimed at presenting the fundamental physics of breakdown, including recent work which has so far appeared only in specialized papers. This has obvious interest for research workers in the field, and all who are in any way concerned with discharge phenomena will find valuable information presented in a most lucid style. For each topic, the author follows analysis by a textual discussion of its significance. The analysis is remarkably complete in itself, but full references (304 papers are listed) are available for the specialist reader, and the discussion presents the conclusions in a most informative manner. Treatment of maintained discharges such as the glow or arc are excluded, the emphasis being on the mechanism which sets the criterion for breakdown.

The first three chapters deal with the fundamentals of the motion of charged particles, ionization phenomena, and electrode processes. Breakdown is then discussed for the lower and higher ranges of gas pressure, and under extreme conditions of pressure. To this point the discussion has been for static voltage and uniform field conditions, but the following three chapters cover static breakdown in non-uniform fields, temporal growth of ionization (probably the most important chapter), and finally breakdown with high-frequency fields. Readers whose engineering interests predominate may at first sight be disappointed at the emphasis on static breakdown, but, as the author points out, there is not yet the quantitative data for the other conditions which would make possible the same logical presentation. Indeed, he is careful to mention important deficiencies in our knowledge, but this does not suppress speculation. Outstanding sections include those on electrode effects, the review of Townsend, streamer and canal theories, discussion of formative time-lag, and the author's concept of flash growth. At the present time, the story is that of the remarkable success of the Townsend theory in covering all cases for which sufficient quantitative data are available. The book conforms to the style of the publisher's monograph series.

HELEN D. MEGAW

FERROELECTRICITY IN CRYSTALS

METHUEN. 1957. 220 PP. 27S. 6D.

The high-permittivity ceramic capacitor and the electrostrictive transducer are engineering applications of ferroelectricity which are to-day well established. In practice, the materials employed are Rochelle-salt and perovskite-type ceramics, of which barium titanate is the most important. In the course of the intensive research which has been carried out everywhere during and since the last war, many other ferroelectric materials of different crystal structures have been discovered. Anti-ferroelectrics, which show dielectric anomalies similar to ferroelectrics but, unlike them, do not possess a spontaneous polarization, have been shown to exist.

This book is concerned with the physical principles underlying the properties of these materials. Its merits are twofold. It contains, for the first time in book form, a full record and discussions of the results of the experimental work carried out to date on ferroelectric and antiferroelectric materials, with a very complete list of references to the original papers. This is followed by a critical discussion of the various theories of ferroelectricity which have been put forward by a number of authors. It is shown that most model theories of ferroelectricity apply only to single cases and have not been able to predict experimental behaviour outside the range of properties which they were devised to fit. Phenomenological theories, in particular that of Devonshire, have provided useful relationships between various quantities without providing a mechanism to explain them.

Dr. Megaw, who has herself contributed a number of important papers in this field, approaches the subject as a crystallographer. This is without doubt the most fruitful approach, but it must also be realized that it is a difficult one. Transitions from the non-ferroelectric to the ferroelectric state are accompanied by very small distortions of the crystal structure. The accurate positioning of the various atoms in these structures requires very refined techniques of X-ray and neutron diffraction, and only the most important cases have yet been studied.

The subject is advancing very rapidly, and it is inevitable that this book will require extensive revision in years to come. It is hoped that the author will keep the subject up to date in future editions.

P. H. HAMMOND

FEEDBACK THEORY AND ITS APPLICATIONS

ENGLISH UNIVERSITIES PRESS. 1958. 348 PP. 35S.

E. B. PEARSON

TECHNOLOGY OF INSTRUMENTATION

ENGLISH UNIVERSITIES PRESS. 1958. 202 PP. 25S.

These two books are the first to appear in a series of Applied Physics Guides under the general editorship of Sir Graham Sutton.

'Feedback' engineering has become such an important aspect of modern technology that the subject is fast becoming a fundamental study for the training of engineers. Nevertheless, it is a subject which is still expanding, and books about it soon become outdated. Thus a new book on servo mechanisms written by one who is actively engaged in research in this field is very welcome. The standard is high and aimed primarily at the young post-graduate physicist and engineer, but the text, which is clearly written and self-contained, will appeal to a much wider category of applied scientists.

The earlier part deals exclusively with linear analysis, and many of the examples used to develop the subject are new as far as textbooks are concerned; gyroscopes as servo elements are described. Although the book is written with an electrical engineering bias, the purely mechanical and hydraulic elements are included. The order of presentation is sound, with detailed references at the end of each chapter. From an introduction to 4-terminal network analysis the author is able to deal with the fundamental principles of feedback, including effects on non-linear distortion and random fluctuations. The need for a study of stability is demonstrated, and two chapters are then

devoted to this aspect with special emphasis on graphical methods. The 'hardware' of control systems is dealt with in detail, with good accounts of the various amplifiers used. The linear section terminates with practical design methods under the heading of 'stabilization techniques'.

By far the most important subject of this book is the treatment of the analysis of non-linear effects. Much of this has not been published before, except perhaps in research reports. The transient and phase-plane methods of analysis are becoming well known, but the newer and more powerful frequency-response methods for dealing with the non-linear stability are still being developed. The longest chapter deals effectively with on-off systems, using the techniques considered in the previous chapters. The book ends with an account of electronic simulators for control systems.

In contrast, the book by Professor Pearson is elementary, there is little mathematics and even in the section on the dynamics of instruments nothing more involved than a second-order equation is used. It is essential, before any physical entity can be controlled, either manually or automatically, that it should be measured. Instruments for manual control usually involve presentation for the eye, but for instruments to fit into automatic-control systems other forms of output are required. The development of fast, accurate measuring devices with suitable outputs forms the subject of instrumentation.

The editor's foreword states that the book sets out to answer the question 'how to design an instrument which will measure a variable quantity accurately and consistently'. Either the editor has not read the book or the author has misunderstood his commission. The book deals excellently with the principles of measurement, the characteristics of moving-element types of instruments, and dynamic accuracies. A further chapter is concerned with the laboratory techniques for assessing instrument performance. The whole of this occupies about a third of the book; the remainder forms a basic introduction to feedback theory and the principles of servo mechanisms. This is a subject which is very difficult to deal with at an elementary level; the principles of feedback are by no means obvious, and a good attempt has been made. Even so, the author has oversimplified in many places, even to the extent of giving the reader a wrong impression. For example, when considering saturation it is said that making the amplifier gain sufficiently low will minimize the undesirable effects.

The book would have been better with a greater content of instrumentation and only a modicum of feedback theory.

F. M. PENNING

ELECTRICAL DISCHARGES IN GASES

CLEAVER-HUME PRESS. 1957. 86 PP. 15S.

This book is presented as a series of essays intended to be of particular interest to 'younger readers'. It was first published, in Dutch, two years after the author's death in 1953, and 'no significant changes have been made in the original manuscript'. At a time of rapid advances in the theory of breakdown, it is clear that the views expressed are dated, and one has some regrets that such a distinguished scientist should be so recorded, and without due reference to subsequent findings that would, undoubtedly, have modified his views. The mechanism of the lightning stroke is not 'satisfactorily explained', and the applicability of Townsend's theory to a wide range of conditions under which its validity had been questioned has now been established.

The subject-matter covers self-sustaining and non-self-sustaining discharges, the breakdown theories of the time, glow discharges, and the positive column. Such a scope in a short book inevitably requires very brief treatment of the individual topics, and this restriction allied to good style and presentation does produce a text well adapted for introductory reading, but there is the danger of such readers not appreciating more recent modifications of some of the fundamental physics of the subject. It is produced as a volume of the Philips Technical Library.

C. J. SAVANT, JR.

BASIC FEEDBACK CONTROL SYSTEM DESIGN

MCGRAW-HILL. 1958. 418 PP. £3 14S.

In spite of the fact that several first-class books have been published during the past five years in the field of feedback control-system design and related topics, this present volume will be welcomed because it attempts to fill the gap between theory and practice. Previous books on the subject have tended to be either theoretical on the one hand or practical on the other.

The design of servo mechanisms has become a highly mathematical procedure, and several new theoretical techniques have been developed to handle control-system design and synthesis. One of the most important of these is the so-called root-locus method, which has proved most satisfactory in practice in facilitating the early stages of design. This book describes the root-locus method in detail and discusses the well-established frequency-response methods and their various adaptations. Moreover, the classical aspects of the subject are well covered, and chapters on the means of obtaining the differential equation of the system and of stabilizing the system are well written. Almost half the book is devoted to essentially practical aspects and to the fundamental components involved in automatic control system developments. The practising engineer will find close correlation between servo components and the theoretical treatment associated with them, and he will welcome particularly the large number of explanatory examples which have been introduced.

As would be expected, the Laplace transform method of handling the equations of motion of control systems is advocated and applied throughout the text. The chapters which, owing to their originality of approach, are the most important are those dealing with the root-locus method; servo-mechanism equalization; the design of d.c. and a.c. equalizers; servo-mechanism transducers; and non-linearities in servo design. Of these, the chapter on non-linear problems is particularly well handled and includes a good introduction to both the 'describing-function' and the 'phase-plane' methods of dealing with special kinds of non-linearities. The method of isoclines is also discussed.

The book will be useful to engineering undergraduates as a sound introduction to the design of automatic-control systems, and it will be of particular value to the colleges of higher technology because engineering aspects of the design problem are always so much in evidence. On the other hand, there is a tendency to restrict the discussion to simple servo systems and to avoid any mention of the more important control aspects which arise in the engineering of large-scale systems. For instance, there is little mention of multi-variable control systems, and the concept of disturbances acting on automatic controls is not introduced in a sufficiently general way. Moreover, no mention is made of the possible applica-

tions of information theory, which appears to have very much to offer to the control-system designer of the future. Few references are made to recent British and European work in the field, and almost all the references are to American work. This is rather unfortunate in the field of non-linear systems because some extremely valuable contributions have been made in this country and in Russia during the past few years.

The book is well written, and the illustrations are first-class. It is recommended as a sound fundamental book on the design of feedback control systems—the practical flavour will appeal to many engineers who are not too familiar with the subject.

L. SHEPHERD

OFF-PEAK ELECTRIC SPACE HEATING

TROUP. 1957. 40 PP. 6s.

This brochure is almost certainly the first work to appear on the subject of off-peak space heating by electricity, and the publishers are to be congratulated on their choice of an author. Mr. Shepherd is one of the foremost authorities on

Industrial Heating Engineer

A photograph included in 'Off-Peak Electric Space Heating', showing thermal insulation of an immersion-heater battery head (Eastern Electricity Board)

The battery consists of a number of separate elements rated at say 5 or 6 kW. The insulation increases the temperature of the element terminals, which must be made more robust than those used with a non-insulated battery head.

---

electric floor warming to-day, and his practical experience with this and other methods of electric heating fully qualifies him to write with considerable authority on a subject which is of current interest. The brochure consists of a reprint of a series of six articles which were published in the *Industrial Heating Engineer* last year.

The six articles discuss the economics of off-peak heating, hot-water and block-type thermal-storage systems, floor warming, estimating energy requirements and future developments; thus they practically cover the subject.

To most engineers running cost is of the greatest importance, and the author gives valuable information for use in estimating, which, together with 'degree-day' calculations, provides a sound average figure of operating cost per season.

This work will be welcomed by the Area Board heating engineer, the heating specialist and the electrical contractor. It not only gives arguments in favour of electrical off-peak heating and its economic advantages, but deals quite adequately with criticisms which have already arisen and which the author shows are completely unfounded.

H. G. M. SPRATT

MAGNETIC TAPE RECORDING

HEYWOOD. 1958. 319 PP. £2 15s.

It is now ten years since S. J. Begum's book 'Magnetic Recording' was published, and it has become something of a classic. Technical advances have been rapid in the meantime, but the record of those advances is widely scattered throughout the literature. Two series of articles, one by Westmijze in the *Philips Research Reports* and the other by Daniel and Axon in the *Proceedings* of The Institution, should be specially noted.

There have been many books on the subject published during this period, but Mr. Spratt's work is the first that has come to the reviewer's notice which justifies consideration as the successor to the one by Begum. It succeeds admirably in bringing together in one relatively small volume the essence of the published research work.

The first chapter is a review of the principles of magnetism (C.G.S. units being used), with emphasis on those aspects of particular significance in the recording field. A shorter chapter follows, on the basic principles of sound reproduction and acoustics, but the compression that is necessary in attempting a sixteen-page précis of so vast a subject really prevents justice being done to it.

A chapter of sixty pages is devoted to the principles of magnetic recording; the subject is well covered, and the chapter closes with a useful bibliography. It is noteworthy that the author chooses to describe all three theories suggested to explain the beneficial effects of supersonic bias, perhaps a wise precaution in the present state of the art. This chapter is one of the best general discussions of magnetic recording yet encountered by the reviewer.

The next three chapters are devoted to the manufacture of coated tape, and they include much material that has not been previously published about the art and practice of tape preparation. Chapters 7, 8 and 9 review the requirements of tape recording and reproducer machines and describe several typical commercial equipments with examples from both extremes of the price range. Two chapters deal with the many usual and unusual applications of recording equipment, while the final chapter discusses the thorny subject of recording characteristic standardization and includes B.S.1568 as an appendix.

The book is well recommended as ably covering the subject at an engineering level. The printing and illustrating are of the same high standard, and the book contains remarkably few errors.

Elections and Transfers

The following elections and transfers approved by the Council are effective from the 10th April 1958.

ELECTIONS

Graduates

A'LEE, William Stanley
ALLEN, Stanley George
ANDREWS, Donald Arthur
ANGLESEY, David
ARCHER, Leslie
ATTWOOD, David Wynne
AYLIN, Harry George
BASTARD, George Andrew
BERESFORD, Thomas Alan
BICKERDIKE, Fred
BLANCHARD, Eric Frank
BRADBURY, Derek
BRADBURY, Robert
BRANDWOOD, Raymond
BREWER, John, B.A.
BROWN, Alan Wallis
BROWN, Leslie Stuart
BROWN, Roy
BUTLER, Albert Roy
CARTER, Gordon Sidney
CHICKEN, John Nelson Stamper
CLARK, Brian Arthur Lawrence
COBB, Derek Edward Charles, B.SC.(ENG.)
CODNER, William Guy
COOPER, Ewart Graham
COOPER, Lt. John Spencer, B.A., R.N.
COURT-HAMPTON, David, B.A.
COX, Michael Hubert, B.SC.(ENG.)
DAVIES, Christopher John, B.A.
DAVIS, Bertram David, B.SC.(ENG.)
DENNIS, Ronald James
DIBDIN, George Hillam
DODD, Eric
ELEY, Michael Knowles, B.SC.(ENG.)
ELLIOTT, William Gordon
EMBREY, Alan James
FALKNER, Louis Keith, B.E.
FERGUSON, Iain Alexander
FINCH, Cyril
FLEMING, John Halliday
FOULKES, Kenneth
FOUNTAIN, Leslie John
GALLIMORE, Gilbert John
GIBSON, Ernest
GRAY, Patrick John
HALLAM, George Alfred
HOBMAN, William
HOGG, William Kirtley
HOLT, Roy
HOOK, Brian James
HULBERT, Keith Michael
HUTTON, Andrew Bruce
JAMES, Ronald Lawrence
JOHNSON, Gordon Charles
KALANIT, Gideon, B.SC.
KEENAN, Alexander
KEETON, Kenneth William
KENNEDY, John
LAMB, John Sedman, B.SC.(ENG.)
LANE, Derek Walter
LAWRENCE, Jeffrey Kenneth
LEVY, Israël, B.SC.
LORD, Stanley Arthur
LOTT, Gwyn, B.SC.
LUMBY, Derik Chantry
MACFARLANE, Michael John, B.A.
MCINTOSH, Herbert Thompson
MARCIANO, Fortunato, DOTT.ING.
MARTIN, John Charles
MASSEY, Robert
MAUGHAN, John Stewart
MONTGOMERIE, Kenneth Brown Cunninghame, B.A.
NASAR, Syed Abu, B.SC., B.SC.(ENG.), M.SC.
NUNN, David Victor Redgate
OAKES, Kenneth Russell
PATEL, Kanjibhai Morarji, B.E.
PEARCE, Brian
PEPPER, Ivan Bertram
PRESTON, Christopher Westbury, B.A.
QUINTON, David Gervaise
READE, George Henry, B.ENG.
RIORDAN, David James, B.SC.(ENG.)
ROBB, Charles Henry
ROBERTSON, William Derrick
ROGERS, Kenneth Albert
RZYMOWSKI, Julian Stanislaw, B.SC.(ENG.)
SEABROOK, John Graham, B.SC.(ENG.)
SHELLEY, Richard Brian, B.A.
SHOME, Saurindra Mohan
SILLER, Miss Joan, M.A.
SINCLAIR, John Neil
SITKOWSKI, Julian, B.SC.(ENG.)
SMITH, James Cadzow
SMITH, John
SPENCER, Charles William
SUTCLIFFE, Graham Stuart
TAYLOR, Derek Malcolm, B.SC.
TAYLOR, George William, B.E.
THOMAS, George Kenneth
THURGOOD, Garry
TRENHOLM, Lawrence Kenneth
TUCK, Harry
UPTON, Charles
VIGAR, Dennis Brian
WALDIE, Robert David, B.E.
WHEABLE, Desmond
WILLIAMS, John Robert, B.SC.(ENG.)
WORSLEY, Howard
WRIGHT, Eric George
WRIGHT, Michael John
ZARDA, Steven Jozef, B.E.

Students

ANDERSON, John Mowat
ARCHER, Alan Robert
ATKINSON, Gerald David
AYLETT, Brian
AYRE, John Kenneth, B.SC.
BACKHOUSE, John Malcolm
BAIRSTOW, Jeffrey Noël
BALDRY, Brian Derek
BARKER, Alan
BARNETT, Christopher Frank
BECKETT, James
BENNETT, Roger Stephen, B.SC.
BOAST, Alan Walter
BOLT, John Leonard
BOND, Robert Frank
BORRIE, John Alexander
BOSLEY, Graham Cyril
BROWN, Robert John
BRYDEN, Eric
BUCKE, David Anthony
BULWER, John Alfred
BURROWS, Raymond
CAHILL, Edmund Christopher, B.SC.
CALVERT, Peter Clive, B.SC.
CHARLES, Emmanuel Kofi
CLARKE, Roy Thomas
CLEGG, David
COATES, Ralph Norton, B.SC.
COCKS, Frank Dennis
COLE, Michael Brian
COURT, David Michael
COUSINS, Andrew Smeaton Rodger
COX, Peter Lawrence
CROOKS, William Ralph
CRYER, Derek Frank
CUNNINGHAM, Donald
CURTHOYS, John Robert Charles
DALRYMPLE, Joseph
DALTON, John Edwin
DANDO, Graham
DARBYSHIRE, Leslie, B.SC.(ENG.)
DAVISON, Peter Leslie

Students (contd.)

DERBYSHIRE, William, B.SC.
DUNFORD, Graeme Wilmor, B.SC.
EAGLESFIELD, Ian
EARLE, Walter
ELLIS, Colin John
ELSON, Keith James
ENGLEFIELD, John Henry
EQUAGOO, George Quashee
EVANS, Christopher John
EVANS, Donald Edward
EVANS, William Martin
EVERALL, Declan Sherlock
FINCH, Geoffrey Paul
FISHER, Eric James, B.SC.
FISHER, Michael David
FORREST, Ian Naismith
FRASER, Archibald Cameron
GADRE, Arvind Trimbak
GIBBS, Terrance Walter
GILLANDERS, Robert
GLEESON, Peter Thomas, B.SC.
GOODMAN, Keith Albert
GOULD, Peter
GRADWELL, Ian
GREW, Richard John McIlroy, B.SC.
GROVES, Lyndon Rees, B.SC.
HALSTEAD, David Barry
HARAN, Nicolas Andrew Wilson
HARRIS, John Godfrey
HARROLD, Stephen Oliver
HENRY, Colin Hannah
HENSTOCK, Maurice Graham
HERBERT, Brian Kenneth
HESTAD, Odd Hallvard
HEWITSON, Leslie Gadsden
HILD, John Henry
HINSON, Robin Howard
HOARE, Leonard Ronald Victor
HOOPER, Richard Burnett
HORROCKS, Michael John
HUCKLE, Derek
HUGHES, David Edward
HUGHES, Michael John
JACOBS, Peter John Stephen
JAMES, Antony, B.SC.
JAYATUNGE, Nihal Gamini Perera
JELLY, Aubrey Bruce
KAIL, John Alan Elliott
KERMODE, Miles Anthony
KNIGHT, Brian
KNIGHT, James
LAING, Paul Stewart
LAMBERT, Michael Anthony
LATHAM, Peter Richard Ernest
LAW, Richard Angus
LEE, John Stuart Fraser
LEIGH-BREESE, Christopher John
LE MAISTRE, Ian William
LIMMER, Robert John
LITTLE, Richard Fred
LITTLER, John Gifford
LONG, John Clifton Ernest
LONGLEY, David Roland
MCATAMNEY, Peter James
MCDONALD, Kenneth
MCDONALD, Michael, B.SC.
MCEVOY, Nicholas Eugene
MACLENNAN, Geoffrey
MCQUEEN, Kenneth Buchanan
MALANI, Ratan Hiranand, B.SC.
MARK, John Richard, B.SC.
MEAD, John Frank
MENSAH, Samuel Kwasi
MERCER, David Stanley
MILNE, Ian
MIRCHANDANI, Ram Kishinchand, B.SC.
MISRA, Krishna Kumar, B.SC.
MITSON, Alan Edward, PH.D., B.SC.(ENG.)
MOFFATT, Arthur Murray
MORRISON, George Leslie
MORROLL, Terence David
NAVARATNAM, Sinnathamby
NIBLOCK, William John
NICHOLLS, Michael Charles Frederick
NIXON, Terence John
NORTHEN, William Patrick, B.A.
OBIORA, Ozegbe
OLLIS, Brian Edward
PAITHANKAR, Yeshwant Govind, B.E.
PARKER, Alan
PARKHILL, Robert Colin
PEGG, Trevor Donald
PERERA, Edward Marcus Anthony, B.SC.
PESTELL, David
PHILPOTT, John Raymond
POLLARD, Dennis James
PONSONBY, John Edward Basil
POOL, William John
PRINGLE, James Alexander Sharpe
RANDALL, Thomas
RAYNER, Alan Malcolm
READ, Peter Walter
READER, John Willingdon
REDHOUSE, Anthony Keith
REEVE, Ivan Beaumont
REILLY, Bernard Colin
ROBINSON, Edward Henry
ROE, Robin David
ROSKILLY, David Stewart
RUMFITT, Colin
RUSSELL, David Michael
RUSSELL, Ian Lawson
RYLE, John William
SAUGEN, Jon Erik
SCHEMEL, Raymond Etienne
SCOTT-KERR, Robert James
SHARMA, Prem Nath, B.SC., B.E.
SHEPHERD, Bryan William
SPINNEY, Glen Francis
SPOONER, Alan
STEGER-LEWIS, Beverley Fergus David
STEVENS, Michael Charles
STILL, John William
STINTON, Richard Owen
SUBRAMANIAM, Ananthnarayan, B.SC.
SUGDEN, James Edward, B.SC.
THOMPSON, Brian Edward
THOMPSON, Brian Henry
WATSON, William Gilfbanks
WHITFIELD, Joseph
WIGLEY, John Cherrington
WILLIAMS, Edward John Curtis
WILLIAMS, John Francis
WILSON, Michael William, B.SC.
WINCH, Peter Ernest
WOOLSEY, Jeremy John
WYATT, John William
YOUNG, Hilary Alistair

TRANSFERS

Student to Graduate

ALLOS, Janan Emmanuel, B.SC.(ENG.)
ASHWORTH, Michael William, B.SC.
BAKER, Gordon Dalby
BEGGS, William
BLIGHT, Roger Stanley, B.SC.
BRIDGWAY, Philip
BURNELL, John, B.SC.(ENG.)
CADDY, Roy
CHARLES, Peter Wilson, B.SC.(ENG.)
COOPER, Stanley John
COUTTS, Francis James
CURTIS, Paul
DABORN, David Albert
DAVIS, Lionel Edward, B.SC.(ENG.)
FAIRBAIRN, Frank Barrass
FEY, Derek Albert Edward, B.SC., B.SC.(ENG.)
FOSS, Richard Charles
FOSTER, David Martyn, B.SC.(ENG.)
FRAMPTON, Richard William, B.SC.
FRENCH, David John
GHOSH, Santi Brata, M.SC.TECH.
GILMOUR, Evan Crawford Falconer
GOLDING, Robert John
GRAINGER, Gordon, B.SC.
GRAY, Clifford Bruce, B.SC.TECH.
GREEN, Roger Donald, B.SC.(ENG.)
GRIFFITHS, Peter, B.SC.TECH.
HASAN, Abdul Sahib, B.SC.(ENG.)
HASLER, Michael Delius, B.SC.(ENG.)

Student to Graduate (contd.)

HAYES, Raymond, B.SC.(ENG.)
HEXHAM, John Keith
HILL, John Patterson, B.SC.
HOWIE, Robert Bruce, B.SC.(ENG.)
HUMPHERIES, Melvin John
INGLE, Edward Arthur
JOHNSTON, Robert Kay
JONES, Anthony David
KHULLER, Amrit Rai, B.A., B.SC.(ENG.)
LEDUU, Idris Ola
LEYLAND, Arthur Stanley, B.SC.
LLOYD, Raymond Michael
LYONS, Edward, B.SC.(ENG.)
MATLEY, Joseph Brian, B.SC.
MATTHEWS, Brian, B.SC.(ENG.)
MILLOR, David Ramsden
MOFFITT, Roger Dalziel, B.A.
MOSS, John Kenneth
NAYLOR, John Antony, B.SC.
PAIGE, John Victor
PARK, James William
PRICE, Francis John William
QUAYLE, Ronald
RACE, Donald Malcolm
RANTZEN, Sub-Lt. Henry John, R.N.V.R.
REEVE, Thomas Charles, B.SC.(ENG.)
SEHGAL, Rajinder Kumar, B.E.E.
SHEEHAN, Vincent Anthony
SHEEN, Patrick Anthony David, B.SC.
SNOOK, James Donald
SPENCE, Thomas Mallorie, B.SC.
STEVENS, Frank Roy, B.SC.(ENG.)
STEWART, Duncan Riddell
TEARLE, David Thomas
THAKOR, Vatsal Pranlal, B.SC., M.SC.(ENG.)
THORNLEY, Richard Frank Maute, B.A.
WALKER, Denis John, B.SC.(ENG.)
WALTERS, David Graham, B.SC.(ENG.)
WELSH, Roger Ogg, B.SC.(ENG.)
WHITE, Roger, B.SC.
WILCOX, Frederick George, B.SC.(ENG.)
WILLIAMSON, Maurice Robert, B.SC.(ENG.)
WILLIAMS-WYNN, Henry Earl, B.SC.(ENG.)
YOUNG, David Gordon

The following elections and transfers approved by the Council are effective from the 15th May 1958.

ELECTIONS

Graduates

AL-MAHTA, Kamil Abdul Adheem
ANDERSON, John Henry, B.SC.
BALFOUR, David, B.A.
BEAL, Charles Francis
BETWISTLE, Brian, B.SC.
BONE, David Gardner
BORONKAY, Attila Denes, DIPL.ENG.
BULLAS, Charles
BURROW, Edwin Michael
CHESTER, Gordon
CHILMAN, Dennis Herbert
CHONG, Kam Wah, B.SC.(ENG.)
CLIGG, Donald
COGAN, Denis Joseph, B.E.
COOKE, Ashley
CRANE, Reginald George
CURTIS, John Henry Cyril
DALY, Joseph John Patrick, B.E.
DANCZEWSKYJ, Bohdan, B.SC.(ENG.)
DEANE, Robert Alan, B.A.
DOVER, William Henry
ELVIDGE, John Edward Hutton
FARMERY, Lawrence Norman
FINDLAY, David
FONTENEAU, Kenneth George
GOUGH, Ernest James David
GOYLE, Devinder Nath
HALLIWELL, Roy
HAMPTON, David Cedric, B.SC.
HARDY, Jacques Philippe Roland, B.SC.(ENG.)
HOWARD, William Francis
HOWSON, Edward Alan, B.SC.
HUMPHREYS, James Patrick, B.SC.
JONES, Alwyn Lewis, B.SC.
JONES, John Richard
KIDD, Alan Lister, B.SC.
LEE, Charles Tet Hien, B.E.E.
LEWANDOWSKI, Stanislaw Jozef
LIMPISTHIEN, Suthon, B.SC.
MACARTHUR, William Joseph
MACCONAILL, Alastair, B.E.
MCCRORY, Robert
MCCRORY, Ronald
MCINTYRE, John
MCNEIL, Colin Clive
MARKS, Albert
MUNDY, Frederick Edward
O'BRIEN, Thomas Alan, B.E.
O'SIOCHRU, Anthony Oisin, B.E.
PELL, Michael John, B.SC.(ENG.)
PHILLIPS, Arthur David
PRASAD, Chintamani
PULLIN, Alfred Gerrard
RAJU, Bendapudi Padma, B.SC., B.E., M.SC.
READ, Brian John
READE, Cyril Arthur
REDFERN, Frank Alastair
RUSHMERE, Michael Frank
SELMES, Brian Arthur
SHAW, James Richard, B.A.
SMITH, Albert William
SODOMSKY, Kenneth Farrell, B.SC.(ENG.)
SOMMERFIELD, Lewis Henry
STEWART, Andrew David Garry, B.A.
SWEENEY, Martin Eamon, B.E.
TIMMIS, Lt. Kenneth Peter Ian, B.A., R.N.
ULLAH, Mohammad Manzar, B.SC.(ENG.), M.SC.TECH.
WAINWRIGHT, David John
WARD, Arthur
WATSON, Martin
WILLIAMS, John Derek
WRIGHT, Ronald Edward, B.SC., M.SC.

Students

AVERY, Roger John
BARKER, Edward Byron
BAXON, Allan
BERRY, Peter John
BITTER, Kenneth John
BLAND, Dudley Moore
BOOTHROYD, Arthur, B.SC.
BRADSHAW, Frank
BURTON, Clifford John
CASTLE, John Michael
CHALMERS, James Ferguson
CHILVER, Brian, B.A.
CONTOS, John
COOKSON, Alan Howard
COX, Bryan David
CRADDUCK, Trevor David
DEVINE, Thomas Patrick
DUFFIN, David Edmund
EDGERLEY, Christopher John
EMERSON, Christopher Ian
FELTHAM, David Reginald
FIELDING, Allan
FIFER, Alan George, B.SC.
FLEMING, David Love
FOGARTY, George William Alexander, B.SC.
FRYER, Michael
GANDHI, Shirish Manilal, B.E., B.E.
GATWARD, John Frederick
GRACIE, Richard Arthur
GREEN, Stephen
GULLIVER, Anthony John
HADDAD, Elfaki Ahmed
HALLAM, Trevor James
HAYNES, Brian Arthur
HINDLE, John Mark

Students (contd.)

HODGKINS, David Edmund
HURLEY, Michael John Mary
INSON, Eric Gilbert, B.SC.
IWEDINOBI, Lazarus Ifeanyichuku
JAYAWEERA, Vernon Hemasiri Arumabadu
JONES, Geoffrey Lloyd
JULEFF, John
KATES, Brian Trevor, B.SC.
KELLY, Stephen, B.SC.
KINGSWOOD, Leslie Douglas
KNAPTON, Frederick William
LANDSKRON, Hansjurgen Paul
LAY, Rodney Kintore
LEWIN, David John
LOFT, Graham Arthur, B.SC.
MABEY, David John
METCALF, William Snowdon
METHERELL, Ivor John
MORTON, Joseph
MURDOCH, Norton Lawrence
MURRAY, Paul Michael
OAKES, Martin
ONWUCHEKWA, Jeremiah Nwokeoru
PALEY, Derek Brian
PARTRIDGE, Brian Cecil
PEARCE, Raymond Albert
RAESIDE, Daniel
RAY, Rabin Kumar, B.SC.
READ, Roland Robert
REYNOLDS, Edward Nixon
RINTOUL, John Howard
ROBERTSON, John Wilson
ROGERS, Bryan Charles
RYE, John
SAMARAKKODY, Upali
SHORE, Thomas Edward
SLATTERY, Robert Lindsay
SMITH, Benjamin Edward
SOPHER, Abraham Sassoon, B.SC.
STUART, Peter Masson
THOMAS, Alun David
WALDRON, Thomas William
WARD, David Victor
WATSON, Peter
WINDISCH, Mark Solomon
WOOD, Stanley, B.SC.
WRIGHT, Peter Emmerson
WU, Nan Wah

TRANSFERS

Student to Graduate

ATKINSON, Malcolm Thewlis
BAMJI, Eruch Jal, B.SC.TECH.
BENSON, David James
CARRICK, Geoffrey
CHIJIOKE, Mark Okoro, B.SC.(ENG.)
COCKBURN, Andrew John, B.SC.
COLE, Edric John Osborn
COTTIS, Frederick Stanley Arthur
DAGLISH, James Hilary
DEAN, Brian George, B.SC.(ENG.)
DOWLER, Ronald Keith
FISHER, George Gilbert
GIBBONS, Philip David
GOLDSTEIN, Samuel, B.SC.(ENG.)
HALL, Peter Anthony Stuart, B.SC.(ENG.)
HARSON, John Beatty, B.SC.
HUTCHINS, Roy, B.SC.
JACKSON, John David, B.SC.(ENG.)
JAMES, Edward Clifford
KAMAL, Aditya Kumar, M.SC., DR.ING.
KEEP, Fl.-Officer Brian Dennis, B.SC.(ENG.)
KENNEDY, John, B.SC.
KIRKWOOD, David Malcolm
KNIGHTLEY, John Leslie
LADITAN, Paul Olaniyi
MCLAREN, Peter Grant, B.SC.
METHUEN, Robert Alexander Holt, B.A.
MITCHELL, James William, B.SC.(ENG.)
MORTIMER, William Raymond
MUDDLE, Barry Adrian
NEWCOMBE, John
OSBORNE, Colin Sidney
OSTLER, Richard Ian, B.SC.(ENG.)
PAYNE, Michael George
PETERS, Antony
POTTER, Stuart Victor, B.SC.(ENG.)
PRIMLANI, Ram, B.SC.
ROY, Amitava Dutta, B.SC., B.SC.(ENG.)
SIMPSON, Michael Dunsmore
SMALLEY, Roy
SMITH, Christopher
SMITH, Ian Campbell, B.SC.
STEWART, Charles McGregor, B.SC.
TEWSLEY, Eric William
UNDERWOOD, Ian Robert Britain, B.SC.
UNDERWOOD, Robin Arthur, B.SC.(ENG.)
WADY, Philip John
WEBSTER, Joseph, B.SC.
WELSH, Joseph
WHEELDON, William Edward, B.SC.
WONG, Ming Yap, B.SC.(ENG.)
WRIGHT, Douglas James

NUCLEAR ENERGY IN AUSTRALIA

Australia's first nuclear reactor was set in operation by the Prime Minister, the Rt. Hon. R. G. Menzies, on the 18th April 1958, when he opened the Atomic Energy Research Establishment at Lucas Heights near Sydney.

Senator W. H. Spooner, Minister for National Development, said that Australia was rapidly building up its atomic energy industry, and production of raw materials such as uranium and thorium was already established. The reactor 'Hifar' at Lucas Heights would enable research to be undertaken into the design of nuclear power reactors to meet Australian needs. Radioactive isotopes would also be produced in the reactor for use in industry, agriculture, medicine and scientific research.

About 1 000 guests were present at the opening ceremonies, including members of Federal and State Parliaments, and leaders of industry, commerce and the trade union movement, as well as representatives of the Churches and universities and Federal and State departments.

LIBRARY ACCESSIONS

**Denotes that the publication is also in the Lending Library. The publications cannot be bought through The Institution; the publishers and the prices are given only for the convenience of members.*

BOOKS

AMERICAN RADIO RELAY LEAGUE 621.39(03)

The Radio Amateur's Handbook. 35th ed.

U.S.A., Rumford Press, 1958. pp. 741. 24 × 17 cm. $4.50.

BARISH, N. (Editor) 37

Engineering Enrollment in the United States

New York, New York University Press, 1957. pp. x, 226. 24 × 15 cm. $7.50.

Chapters by various authors surveying the growth of engineering education in the U.S.A., including a review of the position in electrical engineering and a chapter on engineering education in the U.S.S.R.

BENSON, F. A. 621.38(076)

Problems in Electronics with Solutions

London, Spon, 1958. pp. x, 219. 22 × 14 cm. 36s. 0d.

Problems and their solutions largely covering electronics courses for engineering degrees. The 282 problems are arranged in 23 groups, covering transients, waveform analysis, valves as oscillators, amplifiers, etc., c.r. tubes, photocells, waveguides, etc.

CHAFFE, G. H., and EDMONDS, P. J. (Editors) 331

Careers Encyclopedia. 2nd ed.

London, Cleaver-Hume, 1958. pp. xvi, 672. 22 × 14 cm. 15s.

Gives brief details of the nature of the work, educational requirements, prospects and other useful information, of over 200 careers.

CLASON, W. E. (Compiler) 413 = 00

Elsevier's Dictionary of Electronics and Waveguides in Six Languages. English/American, French, Spanish, Italian, Dutch and German.

London, Cleaver-Hume, 1957. pp. viii, 628. 23 × 16 cm. £4 10s.

Contains over 2 000 electronic engineering terms. It indicates English and American usage and uses British Standard and I.E.C. definitions where possible.

FRÖHLICH, H. 537.226

Theory of Dielectrics. Dielectric Constant and Dielectric Loss. 2nd ed.*

Clarendon Press: Oxford University Press, 1958. pp. vii, 192. 22 × 14 cm. 30s. 0d.

A systematic account of the theory of dielectric constant and of dielectric loss, written for applied scientists. Some knowledge of atomic and molecular physics, statistical mechanics, and electrostatics is assumed, together with an understanding of the calculus.

GROVER, J. H. 621.396.933

Aircraft Communications Systems*

London, Heywood, 1958. pp. vii, 127. 22 × 14 cm. 22s. 6d.

Gives details of British air-to-ground communication equipment. It gives theoretical diagrams and describes the circuits used with setting-up and practical operating instructions. V.H.F. transmitters/receivers, contemporary American equipment, and ancillaries are also discussed.

HALL, A. S. 518.3

The Construction of Graphs and Charts

London, Pitman, 1958. pp. xii, 172. 22 × 14 cm. 25s. 0d.

Intended for university students, this books deals with Cartesian and polar co-ordinates, change of variable, graphical differentiation, and integration, intercept charts and nomograms.

HAMMOND, P. H. 621–52

Feedback Theory and its Applications*

London, English Universities Press, 1958. pp. xv, 348. 22 × 14 cm. £1 15s.

A book for post-graduate students which presents well-tried methods of linear and non-linear feedback system analysis. Some familiarity with the Laplace or Heaviside operational method is assumed. This book is reviewed on p. 333.

HERBERT, J. (General Editor) 413 = 00

Conference Terminology. A Manual for Conference Members and Interpreters in English, Russian, French, Italian, Spanish, German.*

London, Cleaver-Hume, 1957. pp. xv, 147. 19 × 13 cm. 12s. 6d.

Gives the essential phrases required by those arranging and attending conferences and meetings. There is a separate index for each language. No guidance is given to pronunciation.

HICKMAN, R. E. B. 534.85

Magnetic Recording Handbook. Theory, Practice and Servicing of Domestic and Professional Tape and Wire Recorders. 2nd ed.*

London, Newnes, 1958. pp. vii, 176. 22 × 14 cm. 21s.

Contains a number of illustrations and diagrams of commercial equipment and a bibliography of references to the literature of the subject.

IOFFE, A. F. 537.32

Semiconductor Thermoelements and Thermoelectric Cooling

London, Infosearch, 1957. pp. 184. 24 × 16 cm. £2 2s.

A translation from two Russian works with supplemental information added to bring it up to date, this book discusses applications of the Peltier and Seebeck effects and new semi-conducting materials for thermo-elements. It will be reviewed in a future issue.

JEWKES, J., SAWERS, D., and STILLERMAN, R. 347.77

The Sources of Invention*

London, Macmillan, 1958. pp. xii, 428. 22 × 14 cm. 31s. 6d.

Part I is a study of the causes and consequences of industrial innovation. It is obviously based on a careful systematic attempt to differentiate between science and technology, invention and development. It considers the effect of building up large research institutes, of monopolies and how far invention can be certain given sufficient support. In Part II a number of important inventions are described. This book was reviewed in the May Journal.

JOOS, G. (in collaboration with I. M. Freeman)

Theoretical Physics. 3rd ed. 53

London, Blackie, 1958. pp. xxiii, 885. 23 × 15 cm. £3 10s.

A book for honours level students.

JUDGE, A. W. 621.75

Engineering Precision Measurements. 3rd, revised, ed.*

London, Chapman and Hall, 1957. pp. vii, 447. 22 × 14 cm. £3 5s.

A survey of the methods, machines and instruments available to-day for engineering measurements. It includes a brief account of 'automatic gauging' and 'work-sizing'.

KEEN, A. W. 621.396.619

Frequency Modulation. An Introduction to the Fundamental Principles*

London, Pitman, 1958 pp. xii, 274. 19 × 12 cm. 30s.

A concise but comprehensive descriptive account of both the transmitting and receiving sides of f.m. broadcasting technique. This book is reviewed on p. 332.

KOROL, A. G. 37

Soviet Education for Science and Technology*

London, Chapman and Hall, 1957. pp. xxv, 513. 23 × 15 cm. £3 8s.

This is a detailed account of the Soviet educational system compared with the American system. It deals in most detail with higher education in the fields of physics and mechanical engineering, comparing curricula with the nearest equivalent of the Massachusetts Institute of Technology. The author has some interesting comments on the strengths and weaknesses of the Soviet system. This book will be reviewed in a future issue.

LABOVITCH, C. (Editor) 37

Directory of Opportunities for Graduates 1958

London, Cornmarket Press, 1958. pp. 215. 22 × 14 cm. 8s. 6d.

Gives brief descriptive details of the size, scope, activities and products of a considerable number of organizations, followed by an indication of the types of graduate required—arts, science, engineering—and the nature of the work, training, location and salary scheme.

LANDEE, R. W., DAVIS, D., and ALBRECHT, A. P.

Electronic Designers' Handbook*

London, McGraw-Hill, 1957. pp. xi, 1049. 24 × 16 cm. £6 8s. 621.38(03)

This handbook not only gives data, formulae, and curves but explanations and worked examples. It covers the whole electronics field, including computer and servo-mechanism techniques.

LAVER, F. J. M. 621.38

Electrons at Work

London, Oxford University Press, 1957. pp. 78. 22 × 14 cm. 7s. 6d.

The basic ideas of electrical communication are explained in the simplest possible manner with an indication of applications in other weak-current fields.

LEWIS, W. W., and GOODHEART, C. F. 538.551

Basic Electric Circuit Theory

New York, The Ronald Press Company, 1958. pp. v, 650. 23 × 15 cm. $9.

The first part of this book deals with the basic principles necessary for the solution of alternating-current circuits. The second half covers the use of hyperbolic and exponential functions, and Laplace transforms, for the solution of problems on filters, transmission lines, and transients. There are problems to be worked at the end of each chapter.

MACFARLANE, J. E. 621.315.3

Teach Yourself Electricity in the House

London, English Universities Press, 1958. pp. 203. 18 × 11 cm. 7s. 6d.

A practical description of the basic principles of electrical installation work for domestic premises. There are many illustrations, plans and helpful diagrams.

MANSFIELD, W. K. 539

Elementary Nuclear Physics*

London, Temple Press, 1958. pp. viii, 60. 22 × 14 cm. 10s. 6d.

One of a series of short monographs on nuclear engineering subjects, suitable for university and technical college students and those who want a broad understanding of the subject. This volume covers the basic physics of reactor design and gives an introduction to radioactivity for those concerned with applications of radio-isotopes. This book will be reviewed in a future issue.

MOIR, J. 534.85

High Quality Sound Reproduction*

London, Chapman and Hall, 1958. pp. xiv, 591. 22 × 14 cm. £3 10s.

This is a comprehensive work covering the whole field from the sound source to the loudspeaker and the acoustic problems of rooms of various sizes. Reproduction in domestic surroundings besides in auditoria is discussed and there is a chapter on stereophonic reproduction. Bibliographical references are given at the end of each chapter. This book is reviewed on p. 333.

MOLLOY, E., and SAY, M. G. (Editors) 621.31(03)

The Electrical Engineers' Reference Book. 9th ed.

London, Newnes, 1958. pp. xxii, 2216. 19 × 13 cm. £4.

A comprehensive work of reference, providing a summary of latest practice in all branches of electrical engineering.

MOLLOY, R. E. (Editor) 612: 621.3

Medical Electrical Equipment. Principles, Installation, Operation and Maintenance of Electrical Equipment used in Hospitals and Clinics*

London, Newnes, 1958. pp. viii, 323. 23 × 16 cm. £1 15s.

A review of the wide variety of electrical equipment in use in hospitals and clinics, giving an indication of the principles involved in each case, constructional and operating details, and in particular the special care needed to ensure safety.

MORGAN, T. J. 621.39.003

Telecommunication Economics*

London, Macdonald, 1958. pp. xv, 452. 22 × 14 cm. £2 10s.

A detailed explanation of the methods used to deal with the economic problems associated with providing the telephone service in this country.

OBERDORFER, G. 53(081)

Die Masssysteme in Physik and Technik. Kritische Untersuchung der Grundlagen zur Aufstellung einwandfreier Masssysteme und Vergleich der bestehenden Systeme in Physik und Technik (Systems of Units in Physics and Technology. Critical Study of the Bases of forming Acceptable Systems and Comparison of Existing Systems).

Vienna, Springer, 1956. pp. vi, 140. 23 × 15 cm.

OLLENDORFF, F. 621.385

Elektronik freier Raumladungen (Electronics of a Free Space-Charge)

Vienna, Springer, 1957. pp. xii, 620. 25 × 16 cm. £8 7s.

This book gives a detailed theoretical treatment of space-charge phenomena in electron tubes. The chapters deal successively with free space-charge (diodes, electron beams, etc.); simple and complex electric control fields (triodes, tetrodes, etc.); space-charge oscillations; the effect of magnetic and electromagnetic fields (in magnetrons, travelling-wave tubes, etc.). There is an extensive bibliography.

PEARSON, E. B. 681.2

Technology of Instrumentation*

London, English Universities Press, 1957. pp. xv, 202. 22 × 14 cm. 25s.

A book for undergraduates and non-specialists. It covers the basic principles and characteristics of measuring instruments before considering the application of instrumentation to servo mechanisms. This book was reviewed on p. 333.

RICHARDS, R. K. 518.5

Digital Computer Components and Circuits*

London, Van Nostrand, 1957. pp. vii, 511. 24 × 16 cm. £3 4s.

Describes circuits suitable for switching, counting, etc., including those in which transistors are used, and also various storage systems which have been developed. This book will be reviewed in a future issue.

ROBIN, L. 517

Fonctions Sphériques de Legendre et Fonctions Sphéroidales. Tome 1. (Legendre's Spherical and Spheroidal Functions)

Paris, Gauthier-Villars, 1957. pp. xxxv, 201. 24 × 16 cm. 4 000 f.

Deals with the use of Legendre functions in mathematical physics.

SCOTT, J. D. 93 : 621.3

Siemens Brothers, 1858–1958. An essay in the history of industry.

London, Weidenfeld & Nicolson, 1958. pp. 279. 25 × 16 cm. 35s. 0d.

The history of the German house of Siemens has already appeared (see below). The story of the British firm, founded not long afterwards, is now told. The early part of this story is largely interwoven with that of Sir William Siemens. It is an interesting account of technical development and the growth of the company during the last hundred years.

SIEMENS, G. 93 : 621.3

History of the House of Siemens. Vol. II. The Era of World Wars.

Freiburg, Alber, 1957. pp. 326. 22 × 14 cm.

This volume continues the story of the German firm, beginning with the First World War and ending after World War II. It discusses technical advances between the wars—in long-distance telephony, broadcasting, electric heating, etc.—and their impact on the economic and industrial development of the firm.

SMITH, J. R. G. 621.39

Elementary Telecommunications Practice*

London, English Universities Press, 1958. pp. xi, 293. 19 × 13 cm. 12s. 6d.

For students preparing for the City and Guilds examination in Elementary Telecommunications Practice.

SPRATT, H. G. M. 534.85

Magnetic Tape Recording*

London, Heywood, 1958. pp. 319. 22 × 14 cm. £2 15s.

Discusses first the basic principles of various magnetic recording systems and the factors affecting the recording characteristics at various frequencies. Then describes the materials used in manufacture, the testing of tapes, and the design and construction of recording machines. Gives examples of special applications and considers likely developments.

SYRETT, J. J. 621.039

Nuclear Reactor Theory*

London, Temple Press, 1958. pp. viii, 80. 22 × 14 cm. 12s. 6d.

The second monograph in the Nuclear Engineering series intended for university and technical college students. It gives a general qualitative description of the fission chain reaction and the concept of critical size. Shows how theories of slowing down and diffusion of neutrons can be applied and conditions for a stable chain reaction obtained. This book will be reviewed in a future issue.

Forthcoming Events

June

25 *Wednesday* Institution Conversazione at the Royal Festival Hall, at 7.30 p.m.

September

s **18–21** *Thursday–Sunday* Section Visit to Edinburgh

Contents of the Current Issues of the *Proceedings*

The date in italics is that of the Journal review or special article. Where given, the date in CAPITALS refers to the month in which a paper was published individually.

PART A. POWER ENGINEERING (JUNE 1958)

P. MCKEARNEY, O.B.E., L. S. DRAKE, AND E. G. MALLALIEU, B.SC. PAPER NO. 2414 U, NOVEMBER 1957
The Development of Variable-Speed High-Power Drives for Large Wind Tunnels *March 1958*

P. MCKEARNEY, O.B.E., L. S. DRAKE, AND E. G. MALLALIEU, B.SC. PAPER NO. 2415 U, NOVEMBER 1957
A Variable-Frequency Power Installation for Large Wind-Tunnel Drives *March 1958*

L. S. DRAKE, J. A. FOX, AND G. H. A. GUNNELL. PAPER NO. 2501 U, DECEMBER 1957
Speed Control of Large Wind Tunnels *March 1958*

T. BARNES AND C. R. DUNHAM, M.A. PAPER NO. 2524 U, DECEMBER 1957
Automatic Setting of the Flexible Walls of a Large Wind Tunnel *March 1958*

D. A. WATT, B.SC.(ENG.). PAPER NO. 2606 U
The Development and Operation of a 10 kW Homopolar Generator with Mercury Brushes *June 1958*

E. T. NORRIS. PAPER NO. 2611
Transformers, Regulators and Reactors *June 1958*

R. HANCOX, B.SC.(ENG.), PH.D., AND H. TROPPER, PH.D. PAPER NO. 2408 M, SEPTEMBER 1957
The Breakdown of Transformer Oil under Impulse Voltages *March 1958*

R. H. DEAN, B.SC.TECH. PAPER NO. 2419 U, OCTOBER 1957
Recent Developments in Medium-Voltage H.B.C. Fuse Links *June 1958*

J. L. DOUGLAS, B.SC.(ENG.), AND A. W. STANNETT, B.SC.(ENG.). PAPER NO. 2473 S, JANUARY 1958
Laboratory and Field Tests on 132 kV Synthetic-Resin-Bonded-Paper Condenser Bushings *May 1958*

W. CASSON AND A. W. HALES. PAPER NO. 2607 S
A Conjugate-Impedance Network Analyser Operating at 50 c/s *June 1958*

Discussion on **Conduction and Induction Pumps for Liquid Metals** before the South Midland Supply and Utilization Group

PART B. RADIO AND ELECTRONIC ENGINEERING (MAY 1958)

See the Journal for May 1958, p. 278.

PART C. MONOGRAPHS (MARCH 1958)

See the Journal for March 1958, p. 158.

ANNOUNCEMENTS TO MEMBERS

THE HOMES FUND

SUMMARY OF CONTRIBUTIONS RECEIVED TO 23RD MAY 1958

	No. of Contributors	£	*s.*	*d.*
£1 000 and over	6	6 000	0	0
£100 to <£1 000	30	6 586	3	0
£5 to <£100	855	9 070	6	7
£2 to <£5	2 075	5 684	11	11
Under £2	23 993	12 442	3	3
		£39 783	4	9

APPOINTMENTS AND NOMINATIONS

COMMITTEE ON REGULATIONS FOR THE ELECTRICAL EQUIPMENT OF BUILDINGS

On the nomination of the Engineer Surveyors' Association, the Council have appointed Mr. J. K. Hadley, ASSOCIATE MEMBER, to serve on the above Committee in place of Mr. D. Whittaker, B.SC., ASSOCIATE MEMBER.

BRITISH NATIONAL COMMITTEE OF THE INTERNATIONAL UNION FOR ELECTROHEAT

The Council have nominated Sir Henry Clay, BART., M.A., MEMBER, to serve as their representative on the above Committee in place of Mr. H. E. Baker, M.A., MEMBER.

B.S.I. SUB-COMMITTEE TLE/1/1—NOMENCLATURE AND SYMBOLS FOR TELECOMMUNICATION

The Council have nominated Mr. L. I. Farren, M.B.E., MEMBER, to serve as their representative on the above Sub-Committee in place of Dr. R. C. G. Williams, B.SC.(ENG.), MEMBER.

B.S.I. COMMITTEE USM/3—STATISTICAL METHODS

The Council have nominated Mr. P. Schiller, DIPL.ING., MEMBER, to serve as their representative on the above Committee in place of Mr. S. Austen Stigant, MEMBER.

ENGINEERING DIVISIONAL COUNCIL OF THE B.S.I.

The Council have nominated Sir Josiah Eccles, C.B.E., D.SC., PAST-PRESIDENT, to continue to serve as their representative on the above Council for the year 1958–59.

NATIONAL ADVISORY COUNCIL OF THE ELECTRICAL ASSOCIATION FOR WOMEN

The Council have nominated Mr. C. T. Melling, C.B.E., M.SC.TECH., VICE-PRESIDENT, to serve as their representative on the above Council in succession to Sir Arthur Fleming, C.B.E., D.ENG., LL.D., PAST-PRESIDENT.*

* The Editor regrets that, in the May *Journal*, the name of Dr. P. Dunsheath, C.B.E., M.A., MEMBER, appeared erroneously in this capacity.

CONVENTION ON RADIO AIDS TO AERONAUTICAL AND MARINE NAVIGATION

The papers and discussions at the recent Convention on Radio Aids to Aeronautical and Marine Navigation will be published at the end of July in a Supplement (No. 9) to Part B of the *Proceedings*. This Supplement—with its contents and index pages, and in a semi-stiff cover—will be complete in a single issue. The prices (post free) are £1 12s. 6d. to members of The Institution and £2 17s. 6d. to non-members. Applications for copies should be addressed to the Secretary.

ENCLOSURES WITH THE *JOURNAL*

Members are asked to note that, commencing with this issue, the separate circulars, notices, etc., which are customarily enclosed with the *Journal* will be found in future *inside the front cover* instead of being placed on the top of the front cover. The change permits wrapping by machine instead of by hand, with some saving of time between printing and posting.

BENEVOLENT FUND

The Court of Governors are pleased to acknowledge further contributions totalling £2 sent by an anonymous donor.

TECHNICAL AUTHORSHIP

The City and Guilds of London Institute have issued details of a new scheme of courses and examinations in technical authorship for those already possessing engineering or scientific backgrounds. A four-year part-time course is envisaged, requiring attendance at a technical college for at least five hours a week, i.e. 150 hours a session. The Intermediate examination will be taken at the end of the second year and the Final at the end of the fourth year, and the Institute's Certificates, of First or Second Class, will be awarded to those who satisfy the examiners. Although the course has been designed principally for younger entrants, the examinations will be open also to practising technical authors.

Both examinations will contain theoretical and practical exercises. The syllabus includes preparation of material, illustration, reproduction, economic and legal aspects, and the administration of a technical-publications department. Further details may be obtained from the City and Guilds of London Institute, Gresham College, Basinghall Street, E.C.2.

INSTITUTE OF RADIO ENGINEERS

The Second National Symposium on Global Communications will be held in St. Petersburg, Florida, from the 3rd to 5th December 1958. It is sponsored jointly by the Professional Group on Communications Systems and the American Institute of Electrical Engineers (Communications Division). Abstracts of technical papers on pertinent subjects should be sent by the 1st August 1958 to Mr. M. R. Donaldson, Electronic Communications Inc., 1501 72nd Street North, St. Petersburg, Florida.

The 1958 Electron Devices Meeting sponsored by the

Professional Group on Electron Devices will be held on the 30th and 31st October 1958 in Washington, D.C. Abstracts of technical papers should be submitted by the 1st August to Mr. S. T. Smith, Code 5240, Naval Research Laboratory, Washington 25, D.C. Subject-matter should concern development techniques and devices, such as valves and transistors, rather than basic research on circuit applications.

COMPUTER DESIGN OF ELECTRICAL PLANT

A five-day symposium on the application of digital computers to the design of electrical plant was held at Queen Mary College, University of London, on the 14th–18th April. It was attended by forty designers from twelve leading manufacturers of electrical machines and transformers.

After introductory lectures on programming design problems and the use of computers in research projects, papers were read on actual experience with the design of power transformers, induction motors, d.c. machines, steam turbines, and turbo-alternators. The overcoming of difficulties encountered in complicated designs was described, and demonstrations were given on various computers.

The symposium concluded with a discussion of future prospects, and it was generally agreed that design offices should begin to train their staff in the use of computers for the analysis of trial designs. It was felt that before long the optimization of final designs could also be left entirely to computers.

A report of the symposium may be obtained, price 10s. (post free), from Queen Mary College, Mile End Road, London E.1.

ULTRA-HIGH-FREQUENCY CONGRESS

The proceedings of the International Congress on Ultra-High-Frequency Circuits and Antennae, which took place in Paris in October 1957, will be published in July 1958 by the Société des Radioélectriciens.

All communications presented at the Congress will be published, in English or French according to the language used by the author. A pamphlet containing abstracts of the communications (published both in English and in French) has also been prepared. The full proceedings will cost 9 000 French francs, and the pamphlet 1 000 French francs.

Further information may be obtained from Congrès Circuits et Antennes Hyperfréquences, Société des Radioélectriciens, 10 avenue Pierre-Larousse, Malakoff (Seine), France.

STATISTICAL QUALITY CONTROL

Birmingham College of Technology will hold a three-week full-time course on 'Statistical Quality Control and Acceptance Sampling' commencing on the 8th September 1958. The course provides the basic training necessary for quality-control engineers. Further details and application forms may be obtained from The Registrar, College of Technology, Gosta Green, Birmingham 4.

SUBSCRIPTIONS AND NATIONAL SERVICE

Under a recommendation approved by the Council the subscription payable by Graduate and Student members during their term of National Service is reduced to 10s. per annum. A member wishing to take advantage of this dispensation should advise the Secretary, giving the date of his call-up.

CORRESPONDENCE

In view of the heavy volume of correspondence received daily at the offices of The Institution it is of the greatest assistance when members, in replying to letters received from the Secretary, quote The Institution's reference number. This saves the time of the routing staff and ensures that a letter not only reaches the department concerned without delay but can be immediately linked with the previous correspondence. It is also helpful when members state their class of membership.

REGISTER OF MEMBERS—CHANGES OF ADDRESS

Members are reminded that notifications of changes of address should be made to the Secretary of The Institution in London. Where a transfer from the area of one Local Centre or Sub-Centre to another arises as a result of a change of address, this transfer is automatically arranged by headquarters, and the member concerned need not notify also the Honorary Secretary of the Local Centre or Sub-Centre.

To obviate the possibility of errors in the records, members are particularly requested, when notifying a change of address, to give their full initials, their previous address and their class of membership.

RETIRED MEMBERS AND THOSE OF LONG STANDING

Members are reminded of a rule which has been in existence for some years and which enables Corporate Members and Associates who have retired from the profession and are still desirous of retaining their membership of The Institution to do so without payment of further subscriptions. It is left to the members concerned to make application to be brought within the rule. The rule, which does not apply retrospectively, is as follows:

Any Corporate Member or Associate who has reached the age of 60 and has retired from the practice of his profession or business may apply to the Council to waive his future annual subscriptions provided that his membership of The Institution has been continuous for at least 25 years. If he desires to continue to receive the *Journal* he can do so on payment of 10s. per annum. Parts A, B and C of the *Proceedings* will also be available to him at the appropriate subscription rates.

In addition to the foregoing, it should be noted that a further rule provides that as soon as a member of any class has completed 50 years of membership he will not be required to pay any further membership subscriptions, regardless of whether he is still in remunerative employment. This rule operates automatically, and the member on qualifying is notified accordingly. If he desires to receive the *Journal* or the *Proceedings* the arrangement for retired members of 25 years' standing also applies.

PRACTICAL PAPERS IN THE *PROCEEDINGS*

The Council welcome the submission, for publication in the *Proceedings*, of short papers dealing with practical problems encountered in the development, manufacture, operation or maintenance of electrical equipment. Such papers are useful to other members facing similar problems. They may be quite short, of any length between, say, 750 and 2 500 words. A short, practical paper has an obvious attraction for the engineer who is too busy to prepare a full-length one, and it provides information in a form which readers can usually assimilate rapidly. It is hoped that more members will write them than at present.

RADIO AND TELECOMMUNICATION SECTION

Stereophonic Disc Recordings

The immense popularity of home music systems among members of all sections of The Institution was indicated by the large attendance of 368 at the informal meeting on the 24th February on *Stereophonic Recording on Gramophone Discs* by Mr. H. A. M. Clark. Both of this session's informal evenings on the subject of high-quality sound reproduction have achieved exceptional attendances.

Sound reproducer systems have a subjective appeal, and this makes it advisable to accompany any talk by an appropriate demonstration. An indication of the performance of a system designed for a small room is difficult to achieve when the attendance is so large, but on this occasion the difficulty was partly overcome by running a continuous series of demonstrations in the common room during the afternoon.

A stereophonic sound system is one that conveys an impression of the size of the original sound source, a characteristic that demands at least two completely separate transmission channels between studio and listeners' room. Mr. Clark dealt in detail with the problems of recording the two separate signals in the single groove of a gramophone record while still maintaining adequate separation between the channels.

From the review of the early history of the art it was surprising to learn that nominal solutions to the problems of recording two signals in a single groove were propounded as far back as 1909, and then at regular intervals until the embracing work of A. D. Blumlein in the late 1920's produced the system that is now nominally standardized by all the recording organizations. The two separate signals are used to modulate a single groove, the two axes of stylus motion being at 90° to each other and at 45° to the record surface. Recordings of this type are claimed to give adequate freedom from crosstalk between channels and to be *compatible* (a blessed word imported from the television field), in that a stereophonic disc will provide a monaural output when played with a normal type of pick-up.

This statement raised sceptical comment from several speakers in the discussion that followed, Mr. P. Wilson and Mr. S. Kelly in particular claiming that the life of the record would be uneconomically short if played with most of the current types of pick-up, though it was not disputed that the monaural information was carried by the two tracks.

Crosstalk between channels impairs the stereophonic image and in the limit reduces the performance to that of a monaural channel. Mr. J. Moir queried the performance obtained in respect of crosstalk, suspecting that stereophonic discs are not as good as stereophonic tape in this respect. Mr. Clark agreed that this was the $64000 question but felt that the performance obtained is adequate though without any great margin of safety; Mr. Kelly differed, claiming that measurements showed that crosstalk on some of the early stereophonic discs to the proposed standards was as low as 8–10 dB. It is clearly very difficult to separate the performance of the disc from that of the pick-up in this respect, and there seems to be little doubt that the pick-up designers have not yet had time to examine the problem in detail.

One speaker, obviously close to the hard facts of life, wanted to know whether stereophonic systems were commercially justifiable when price must have primary consideration, but this was a point which nobody was bold enough to take up in discussion. Perhaps it is a question that only time and experience can answer, for public reaction is notoriously difficult to forecast.

It is a regrettable fact in the sound reproducer field that common standards tend to emerge only as a technique is about to be superseded by a later development, a point raised by Mr. Ross. Stereophonic disc recording appears to be the exception. Though none of the national standardizing institutions has yet issued any official directives, there has been a high standard of co-operation between all the recording companies.

It was a most interesting evening, the good attendance suggesting that The Institution should hear more from the exponents of the sound reproducer art. J. M.

SUPPLY SECTION

In-step or Out-of-step?

On the 26th February, at a Supply Section meeting in the Institution building, a cunning plot to undermine the supremacy of the synchronous generator was frustrated by the combined efforts of manufacturers, consulting engineers, and the supply authority.

In his paper on *Design and Application of Large Solid-Rotor Asynchronous Generators* (reviewed on p. 313), Mr. P. Richardson suggested that, in large cross-compound turbo-generator units which have two shafts and two generators, one of the generators should be synchronous and the other asynchronous.

To the onlooker this seemed a modest proposal from which no one with a sense of fair play could reasonably dissent. But whether the supporters of the synchronous generator regarded this suggestion as the thin end of the wedge, or whether they were incensed at an infringement of prerogative, the result was a resounding victory for the 'in-steppers' over the 'out-of-steppers', of which latter party the author appeared to be the only representative present.

Arguments of a technical nature were advanced on both sides, but these seemed strangely irrelevant to so serious an issue. Speaking from the designers' point of view Mr. W. N. Kilner and Mr. V. J. Vickers forecast excessive end-heating in asynchronous generators, and drew attention to the low output obtainable at lagging power factors, while Mr. V. Easton thought the author's approach to end heating was oversimplified.

Mr. L. W. James showed no anxiety to be rid of field windings now that creep troubles had been largely overcome. He dealt the author's arguments a heavy blow when he disclosed that economic studies had shown a 2-pole generator to be advantageous on the low-pressure line of a cross-compound unit. Dr. W. J. Gibbs, whose work had been referred to in the paper, was clearly disturbed at the lack of any definite policy on damper windings.

Mr. D. P. Sayers suggested an immediate use for the extra

losses produced by an asynchronous generator. All those present, on that chilly February evening, concurred.

In replying to the discussion the author agreed that his proposal had a more restricted application than the paper indicated, but he knew of a system in the Canadian prairies where an asynchronous generator would be just the thing. In saying this he scored a palpable hit, since previous speakers had prophesied that asynchronous generators would be a dead loss anywhere. There was some consolation, however, in the thought that the prairies were a long way off.

If the discussion erred on the side of conservatism this may have arisen from feelings which Mr. Vickers summed up when he said: 'It is good to be in the van, but it is better to keep out of the cart.' C. P. H.

The Objective of Euratom

The Supply Section Annual Lecture was given this year on the 26th March by Professor F. Giordani, and in seconding the vote of thanks Dr. J. R. Mortlock was brave enough to voice the vagueness about the objects and achievements of Euratom with which so many of us had approached the lecture. At ease in our language, Professor Giordani firmly disposed of our vagueness and invested a very statistical subject with a clear sense of purpose. He drew an arresting parallel between mankind's preoccupation at an earlier stage with food supplies and the anxiety in our own times about power supplies. He referred to the misgivings of the economist Malthus, in 1798, about the ability of the world to feed the rapidly growing population, and the escape from that situation pointed out a century later by Sir William Crookes which could be, and later was, achieved by the fixation of nitrogen and the consequent limitless potentialities of production of artificial fertilizers. He compared this with the increasingly gloomy preoccupation during the inter-war period with the growing rate of exhaustion of the world's fossil-fuel supplies and the growing hope of an escape from the situation raised by the accumulating knowledge of radioactivity, the splitting of the atom, and the prospect of harnessing nuclear power. He emphasized how the virtual achievement of these hopes in the last decade by the harnessing of the fission process has shifted our anxieties a long way further into the future, and how the exploitation of the fusion principle may well bring us release from this anxiety for all time.

Of the seven Euratom countries—Britain, France, Western Germany, Belgium, Holland, Luxembourg and Italy—he sketched the special part played by Britain in having herself tackled and brought first to practical achievement the problem of nuclear generation. To-day these seven countries import some 20% of all their fuel requirements. A great deal of thought by Professor Giordani and the two other expert investigators appointed by the Council of the O.E.E.C. has gone into assessing the future trends and requirements of these countries, and the various estimates of the rates of growth and consumption of all fuels range from 2·5% to 4·3% per annum. Professor Giordani himself is inclined to accept a value of 4% per annum on a long-term basis. Were it not for nuclear energy the continuation of this trend would lead to the Euratom countries importing 37% of their total fuel by 1975. Professor Giordani declared that with the Euratom plan it is confidently hoped that all future growth of power requirements beyond about 1967 will be met from nuclear sources. The necessary supplies of nuclear fuel have, in effect, been guaranteed by the United States and Britain. In this way, any greater dependence on fossil-fuel supplies from the New World or the unstable Middle East will be avoided.

Professor Giordani has himself been identified with much of the appreciation and planning of the earlier nitrogen resources as well as the present power ones. He told us how, in 1925, at a Conference in Bucharest, the new synthetic ammonia was likened to a young woman, highly admired but rather capricious and difficult to approach, and that, on the other hand, the established calcium cyanimide was likened to a middle-aged man, full of strength and self-confidence. In his reply at that time Professor Giordani is recorded as saying that the synthetic ammonia, though capricious and scarcely reasonable, had in front of her—like all nice girls—a future of endless success. He applied this statement to-day to the case of nuclear energy and, notwithstanding his age, confirmed his belief in the unfailing success of youth and beauty when wisely united with reasonable prudence.

In proposing the vote of thanks, Mr. J. D. Peattie paralleled the news which Professor Giordani and his two wise colleagues had brought us with the glad tidings brought by the earlier three wise men. J. E. L. R.

UTILIZATION SECTION SUPPLY SECTION

Furnaces and Flicker

At the joint meeting of the Utiiization and Supply Sections on the 13th February, presided over by the Chairman of the former, a paper on *Supply-Voltage and Current Variations produced by a 60-ton 3-phase Electric Arc Furnace* was presented by Dr. B. C. Robinson and Mr. A. I. Winder. The paper, which is reviewed on p. 314, recorded the various tests carried out on such a furnace for steel melting, connected to the 66 kV system through a 66/11 kV 15 MVA transformer, in order to determine what effects it had on the supply network. Among these effects were voltage fluctuations on the 11 kV line from about 75 to nearly 150% of normal voltage, and, in this connection, it was calculated that about 17% of these variations were produced on the 66 kV network. Also, it was found possible to observe fluctuations from this cause on the lighting supply about two miles from the furnace.

During the initial period of a melt, current fluctuations on the 11 kV supply were found to take place several times a minute with an amplitude of several hundred amperes, and as the charge began to melt unbalanced currents of about 1 500 amp occurred on the 11 kV system.

It was interesting to learn that both the use and size of electric arc furnaces are increasing for the production of steel.

Bearing all these factors in mind, one could not help feeling that the view of the authors—that an electric arc furnace has long been recognized 'as a rather difficult load for the supply engineer'—no doubt savoured somewhat of a masterly understatement to those members present who were engaged on the supply side of the industry.

The discussion was opened by Mr. F. Seddon, who indicated the probable trend of arc-furnace development in the immediate future. In this connection, he said that one steel manufacturer was considering the installation of a 45 MVA furnace, and that it had been calculated that in the Sheffield area alone the replacement of the present open-hearth furnaces by arc melting furnaces would involve an additional load of some 1 000 MVA on the supply system.

Several speakers referred to the use of series and shunt capacitors, synchronous condensers and combinations of both as a means of eliminating the flicker effect, although it

was readily recognized that a considerable amount of study would have to be given to this particular aspect of the subject.

One contributor stated that the switching surges on the system with respect to a 30 MW calcium-carbide furnace produced voltages reaching approximately twenty times the normal peak voltage to earth at the furnace, while another pointed out that the value of fast electrode control had been stressed in America, where investigations into methods to achieve this were being carried out.

The suggestion was also made that up to 50% more money could quite justifiably be spent on the design of the furnace itself, with a view to the prevention of voltage fluctuations, if the cost of other methods of elimination (e.g. by means of capacitors) were taken into consideration.

After the authors had replied to the discussion, a vote of thanks was proposed by Mr. J. D. Peattie, a Past-Chairman of the Supply Section. R. H. R.

UTILIZATION SECTION

Fuse Links

At the meeting of the Utilization Section held on the 16th January, Mr. R. H. Dean presented a paper entitled *Recent Developments in Medium-Voltage H.B.C. Fuse Links*, in which it was pointed out that the difference in the specialized requirements of cartridge fuse links for the United States and Canada, compared with those for Great Britain, are both physical and electrical. In this connection, an account was given of the development work which had been carried out in this country in the investigation of fuse links of ratings up to 600 volts and 600 amp with regard to basic problems of design in order to comply with North American specifications, which had led to the choice of a design to satisfy these requirements. Some details of performance were also provided of the resulting range of fuse links, and reference was made to a novel method for rapidly estimating the effect of a fuse link in limiting fault power and energy admitted to a protected circuit under severe fault conditions. Incidentally, it was interesting to observe from the nomenclature in this paper that the preferred term for the h.r.c. (high rupturing capacity) fuse is now 'h.b.c.' (high breaking capacity).* A review of the paper appears on p. 316.

The discussion was opened by Mr. J. W. Gibson, who said that in North America there had not been the same care as in this country in keeping down fault currents by sectionalizing distribution systems, such currents for a solid fault being approximately twice as large, and this fact was matched by the breaking capacity required by the Canadian standard. He also referred to the general experience that fuses usually acted more quickly for a given current than was indicated by calculation.

One speaker felt that a paper dealing with this particular subject was long overdue, as the last one on fuses, he believed, had been presented more than ten years ago, and the view was expressed that the present paper represented a serious attempt to match the performance of the fuse to that of the circuit it had to protect. The advantage was also questioned of utilizing dual-element fuse links in back-up protection of motor starters, since the overload trips would always take care of small over-currents.

As could be expected with a paper of this character, a number of members on the designing side of the profession contributed to the discussion, and it was interesting to note the differences of opinion which existed among them regarding certain items, e.g. the susceptibility of copper to the M-effect.

During the course of his reply to the discussion, the author paid tribute to the value of the work of the Electrical Research Association, when he said that anybody concerned with fuse design who got 'stuck' with a mathematical formula would be well-advised to refer to the relevant reports issued by that body, where a solution could usually be found. R. H. R.

* The standard term in the United States and Canada is 'h.r.c. fuse'; we understand that the British Standards Institution frowns on ruptures.—Editor.

ORDINARY MEETING

Cliff Quay

A large audience at the Ordinary Meeting on the 6th March 1958 heard and discussed accounts of what are likely to become classic tests on power-system stability carried out at Cliff Quay in August 1957. Two papers were presented: *The Organization of Large-Scale Grid System Tests* by F. H. Last, E. Mills and N. D. Norris, and *Results of Full-Scale Stability Tests on the British 132 kV Grid System* by F. Busemann and W. Casson. The President was elsewhere engaged on our behalf,* but the members present at the meeting were happy to see Sir Archibald Gill in the chair again.

The papers were presented by Mr. Mills and Mr. Casson. Mr. Mills, in outlining the precautions to be taken in such a large-scale undertaking, was able to assure us that these precautions had been fully tested by a wandering lightning storm, and he showed a film illustrating clearly the problems and apprehensions of a control engineer confronted by instability. Mr. Casson described the purpose of the tests broadly and in detail and summarized the main conclusions, which mostly related to the transient behaviour of synchronous machines and their controls. The papers are reviewed on pp. 317 and 319.

Mr. L. Gosland opened the discussion, outlining the background of the tests, and some of the technical lessons and questions resulting from them. Similar studies should perhaps be made on hydro-electric systems. Mr. F. J. Lane stressed the complexity and cost of full-scale tests, and added some points of good management, in particular that staff at all levels should be informed lest they worry about the implications of unusual and unexpected instructions. There was, he added, always need to control the 'enthusiasts' who wished to use such occasions to further their own particular technical interests. He deprecated the hesitancy in the conclusions derived from the results of the tests, and he insisted (with poetic inspiration) on the need for confidence in protective gear.

Mr. M. Magnien, a known and welcome visitor from the Société Française des Électriciens, told of the interest the papers had aroused in France, commenting on the admirable teamwork exhibited. He elaborated the circumstances in which high losses at the start of a short-circuit have an important effect on critical switching times, and mentioned some proposed modifications to the Électricité de France micro-machines to improve their representation of these losses. Mr. W. N. C. Clinch was interested in the results of switching unexcited machines onto the system, commenting on the different human reactions to expected and to unexpected events. The tests should prove of great value to manufacturers.

Mr. D. R. Fenwick brought a new point of view to the consideration of voltage regulators. He questioned the extent

* Mr. T. E. Goldup was on a world tour of the Groups and Branches of The Institution overseas.

to which the steady-state stability could be assisted by the type of voltage regulator used, which has by design a zone, albeit narrow, of insensitivity. For true stability, a continuously acting regulator was required. He showed what could be done with a modern regulator of magnetic-amplifier type with high gain. Mr. B. Adkins, acknowledging the value of tests of the type described, stressed that these studies of 'how' must be backed by others of 'why', and told the meeting something of his work in this direction.

Contributions from some of Mr. Lane's 'enthusiasts' showed that the control exercised over them had not been so severe as to frustrate their efforts. Professor M. W. Humphrey Davies illustrated the application of phase-plane diagrams to the study of stability. Asymmetric response of governors would help resynchronization. Mr. T. M. Whitelegg, who had taken part in the Cliff Quay tests, spoke of the method of control to which he himself had been subjected and mentioned the value of the daily discussions of the assembled experts during the days and evenings while the series of tests lasted. The indications of control-room instruments might not be so alarming in service as on tests, since their motions would be attenuated by the time the operator became aware of them. Mr. R. E. Martin supported the advocacy of training on simulators for control staff and gave an interesting account of the progress of instrumentation for field work.

Mr. J. S. Vosper showed how well the restriking voltage transients, following the interruption of fault currents during the tests, agreed with calculation; the tests had produced some new information on the short-time transient behaviour of machine windings. Mr. P. D. Aylett discussed the nature of the large initial losses in machines on short-circuit. More information was required on the characteristics of governors, which may act to give negative damping. He had great confidence in the ability of machines to resynchronize after an instability. Mr. E. B. Powell outlined the results of his early experiments, indicating high initial losses, and lauded the virtues of the simple attack by slide rule on stability problems. He wanted more analysis of governor behaviour; what was relevant was the performance, not of the primary relay, but of the servo motors and valve gear.

To this exhaustive, and on the whole relevant, discussion, Dr. Last and Dr. Busemann replied nobly, accepting what was possible but not forgetting to promise dissent on some points in a written reply. A vote of thanks, moved in characteristically comprehensive and precise terms by Professor M. G. Say, terminated the proceedings. L. G.

NEWS *from the Centres*

NORTH MIDLAND GRADUATE AND STUDENT SECTION

Week-end Visit

The North Midland Graduate and Student Section organized a joint week-end in Leeds on the 12th and 13th April, and acted as hosts to members of the surrounding Sections. Fifty-nine people attended this new venture in Graduate and Student activities, including members and their ladies from Sheffield, Liverpool, Tyneside, Loughborough, Nottingham, Birmingham, Manchester and, of course, Leeds.

The week-end began with a reception and formal opening by the Chairman of the North Midland Graduate and Student Section, Mr. H. Myers, at the English Electric Co., Bradford. This was followed by a tour of the works and an excellent lunch. The party then left by car or coach for Weetwood Hall, a hostel of the University of Leeds, which provided overnight accommodation. During the afternoon films were shown in the lounge and tea was served.

On Saturday evening a dinner and dance, sponsored by the Yorkshire Switchgear Co., was held at Castle Grove, Leeds. Several guests were invited whose co-operation had made the week-end possible. The Chairman of the North Midland Centre, Mr. A. J. Coveney, was present and replied to the toast of the Guests proposed by the Chairman of the Graduate and Student Section. Some tickets were also available for members of the North Midland Centre who were not taking part in the other activities. Ninety-seven people were present, and a competition raised £10 for the Benevolent Fund.

The 'joint week-enders' were up early next morning to visit Ferrybridge power station, Monk Fryston 275 kV switching site, or Low Road substation, Leeds. The first two

Outside the offices of the English Electric Co., Bradford

visits were arranged by the kind permission of the Yorkshire Division of the C.E.G.B. and the third by the Yorkshire Electricity Board.

The weather throughout was warm and sunny, and Sunday afternoon was all too short for the visitors, who had the choice of a guided tour of York, a trip to the Castle Museum or of wandering as they wished through the city.

The week-end closed with afternoon tea at the Royal Station Hotel and a farewell speech by Mr. D. Pitts, the Organizing Secretary. Mr. Pitts expressed a hope that other centres would follow the example set by the North Midland Centre.

The success of the week-end was very gratifying to the organizers and was attained only through the generosity of several firms and bodies and through the kindness and encouragement of a number of senior members, including the Chairman and the Committee of the North Midland Centre.

H. M.

SCOTTISH CENTRE

Making History

A record number of 168 members and guests assembled for the Edinburgh Dinner of the Scottish Centre on the 20th March under the chairmanship of Mr. E. Openshaw Taylor, the Centre Chairman. The chief guest was Lt.-Col. D. H. Cameron of Lochiel, and the Centre regarded it as a great honour that the toast of The Institution should be proposed by the 26th Chief of the Clan Cameron. As well as taking part in many other activities, Col. Cameron of Lochiel is a member of the British Transport Commission, and in his speech he referred to the great opportunities offered by the electrification programme being carried out by the Commission. Mr. C. T. Melling, Vice-President, responded and undertook to send to the President and Secretary, who were in Australia, the best wishes of the Scottish Centre for the remainder of their world tour. Mr. D. Chandra, Chairman of the South-East Scotland Graduate and Student Section, added his quota to Scottish Centre history by being the first Student Chairman to speak at a Dinner; the excellence of his speech leads one to hope that this will become a regular feature of the Edinburgh Dinner. The Chairman introduced a surprise item by bidding *au revoir* to Mr. J. L. Egginton, who was leaving Scotland to take up an appointment elsewhere; on behalf of those who had worked with Mr. Egginton during his service as Honorary Secretary of the South-East Scotland Sub-Centre, in the formation of which he had played a leading part and towards the success of which he had made a major contribution, the Chairman presented him with an inscribed cigarette box. The Dinner concluded with the toast to the Chairman, very effectively proposed by Professor E. G. Cullwick, Chairman of the North Scotland Sub-Centre.

North of the 58th Parallel

On the 24th March the North Scotland Sub-Centre organized a District Meeting at Thurso. In his introductory remarks Professor Cullwick pointed out that this was the first time that any meeting of The Institution had been held north of the 58th parallel. A gathering of about sixty members and visitors heard Mr. R. J. Rennie give a paper prepared by himself and Mr. J. S. Pickles on *A Visit to Russia*. This was followed by a lively discussion. In thanking the lecturer, Maj.-Gen. S. W. Joslin of the Dounreay Atomic Energy Establishment congratulated The Institution on having held a meeting so far from their normal centres of activity and hoped that the other major Institutions would follow suit.

Invoking the Constitution

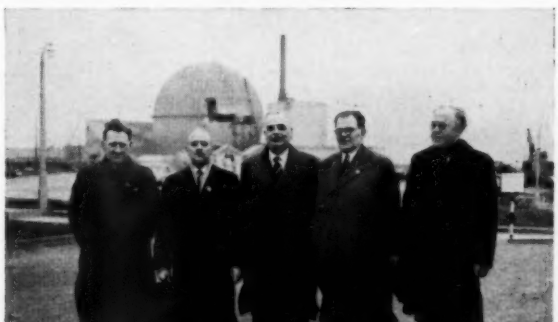
The Annual General Meetings of the three Scottish Sub-Centres take place at the beginning of May. A unique situation arose in the South-East Scotland Sub-Centre in that both Vice-Chairmen have recently left Scotland to take posts elsewhere, so that, to conform with the constitution, it was necessary to invite a Past-Chairman to serve as Chairman for 1958–59; the present Chairman, Mr. J. Mendelson, consented to continue in office for a second year, and this was confirmed at the meeting in Edinburgh on the 29th April. The formal business of the meeting was followed by the customary two short papers from a Graduate or Student member and from a Senior member; the first was by Mr. P. Danahay, Secretary of the Graduate and Student Section, on *Distribution-System Planning*; after hearing this excellent paper and the subsequent discussion the audience felt quite confident that some part, at least, of the future planning of our distribution system was in very safe hands. The second paper, by Mr. F. G. Bennett, was entitled *Ups and Downs* and proved to be about mountain climbing; Mr. Bennett gave an extremely amusing talk but also managed to include a serious discussion on the philosophy of mountaineering; the talk was illustrated by a large number of lantern slides, many of which were of historic interest and seemed to imply that the erection of scaffolding around a peak was a justifiable means of ascent; interspersed among these illustrations, however, were many magnificent coloured views of Scottish mountains.

The meetings of the South-West and North Scotland Sub-Centres were held in Glasgow and Dundee on the 7th and 8th May respectively, when Mr. W. Adam in the South-West and Mr. S. R. Urquhart in the North were elected Chairmen for 1958–59. In both Sub-Centres the formal business was followed by the film *Atlantic Link*, describing the laying of the transatlantic telephone cable. In Glasgow there was also

---

Scottish Centre District Meeting at Thurso

Posed in front of the reactor sphere at Dounreay are (from left to right) Mr. T. M. McLammont, Hon. Sec. of the North Scotland Sub-Centre, Mr. R. J. Rennie, Vice-Chairman of the Scottish Centre, Maj.-Gen. S. W. Joslin, Works General Manager at Dounreay, Mr. E. O. Taylor, Chairman of the Scottish Centre, and Professor E. G. Cullwick, Chairman of the North Scotland Sub-Centre.



a second film entitled *French Performances*; although these turned out to be technical performances the film was very much enjoyed. E. O. T.

SHEFFIELD SUB-CENTRE

Welcoming a White Area

The meeting at Grimsby on the 24th April was of particular interest in the affairs of the Sub-Centre, since it was the first such meeting to be held there following the recent inclusion of the northern part of the previous Lincolnshire white area within its boundary.

A small contingent from Leeds and a larger one from Sheffield made the journey, of over eighty miles in each case, to recognize the event, and joined with the speaker and some of the local members at dinner before the meeting, which was attended by seventy-three members and visitors.

To mark the occasion, Mr. A. J. Coveney, Chairman of the North Midland Centre, gave an explanation of the changes, recently approved by the Council, in which the previous Lincolnshire white area has been divided by a line from Gainsborough to the coast just above Mablethorpe, the area north of this line now coming within the boundary of the Sub-Centre.

He also gave an interesting survey of the division of membership between the North Midland Centre, with its two Districts at Hull and Catterick, and the enlarged Sub-Centre.

Dr. O. I. Butler, Sub-Centre Chairman, who presided, welcomed in particular the members from the additional area, explaining the facilities available to them, and offered every assistance from the Sub-Centre Committee.

Mr. D. F. Oakeshott then read the paper *Choice of Insulation and Surge Protection of Overhead Transmission Lines of 33 kV and Above*, of which he is the joint author with Mr. A. Morris Thomas.

The paper, based on a recent E.R.A. report, was a résumé of the effects of transient over-voltages on overhead line systems, mainly in regard to lightning strokes, and of general recommendations on the selection of methods and insulation levels to give reasonable protection.

This roused an interesting discussion, which, in general, asked for more detailed information on the application of safeguards for particular conditions. Mr. G. L. Mason, who opened the discussion, suggested that the advantage of lightning protection from earth wires disposed above the line conductors was outweighed by trouble from conductor clashing when the line was exposed on higher ground, and for these conditions he advocated the all-insulated line with conductors horizontally disposed, surge diverters at line terminations, and high-speed switchgear.

The author was also questioned on the best locations for surge diverters and co-ordinating gaps.

In the usual less formal discussion after the meeting, it was suggested that ordinary scientific methods had not yet caught up with Greek mythology in the understanding of lightning, and that Zeus still had the answer to some of our present devices. Perhaps a study of astrology and the preparation of horoscopes for any apparatus exposed to lightning hazards should be considered.

Dr. F. A. Benson proposed a vote of thanks to Mr. W. S. Milner, convener of the Hull District Meetings, who had made the original arrangements for the meeting, to Mr. E. Cockroft and Mr. J. W. Ledgard of Grimsby for the detailed arrangements, and to Mr. D. F. Oakeshott for the interesting presentation of his paper. L. F. S.

NEWS *from Abroad*

'IRAQ AND PERSIAN GULF JOINT OVERSEA GROUP

At the Display Centre of the Kuwait Oil Co. at Ahmadi, twenty miles south of Kuwait town, on the 23rd February, Mr. M. M. Zahlan read his paper on *The Manufacture and Properties of the Kuwait Sand-Lime Brick* to sixty-three members and guests of the Joint Oversea Group.

In the eighteen months since the plant came into operation, experiment and production have developed until the best proportions of the constituents are known, and the output is close to the design figure of forty million bricks a year. The manufacture of other shapes is now under consideration. The natural colour of the bricks is off-white, and, apart from the pigments used in producing coloured bricks, all raw materials and fuel are indigenous to a country which lacks perennial fresh water and knew nothing of mechanized industry ten years ago.

On the 28th February Mr. G. F. Kennedy introduced a film, *Power for Uganda*, and afterwards dealt very ably with questions covering economic, engineering and sociological aspects of the barrage across the river Nile and the generating station at Owen Falls.

Visit of the President and Secretary

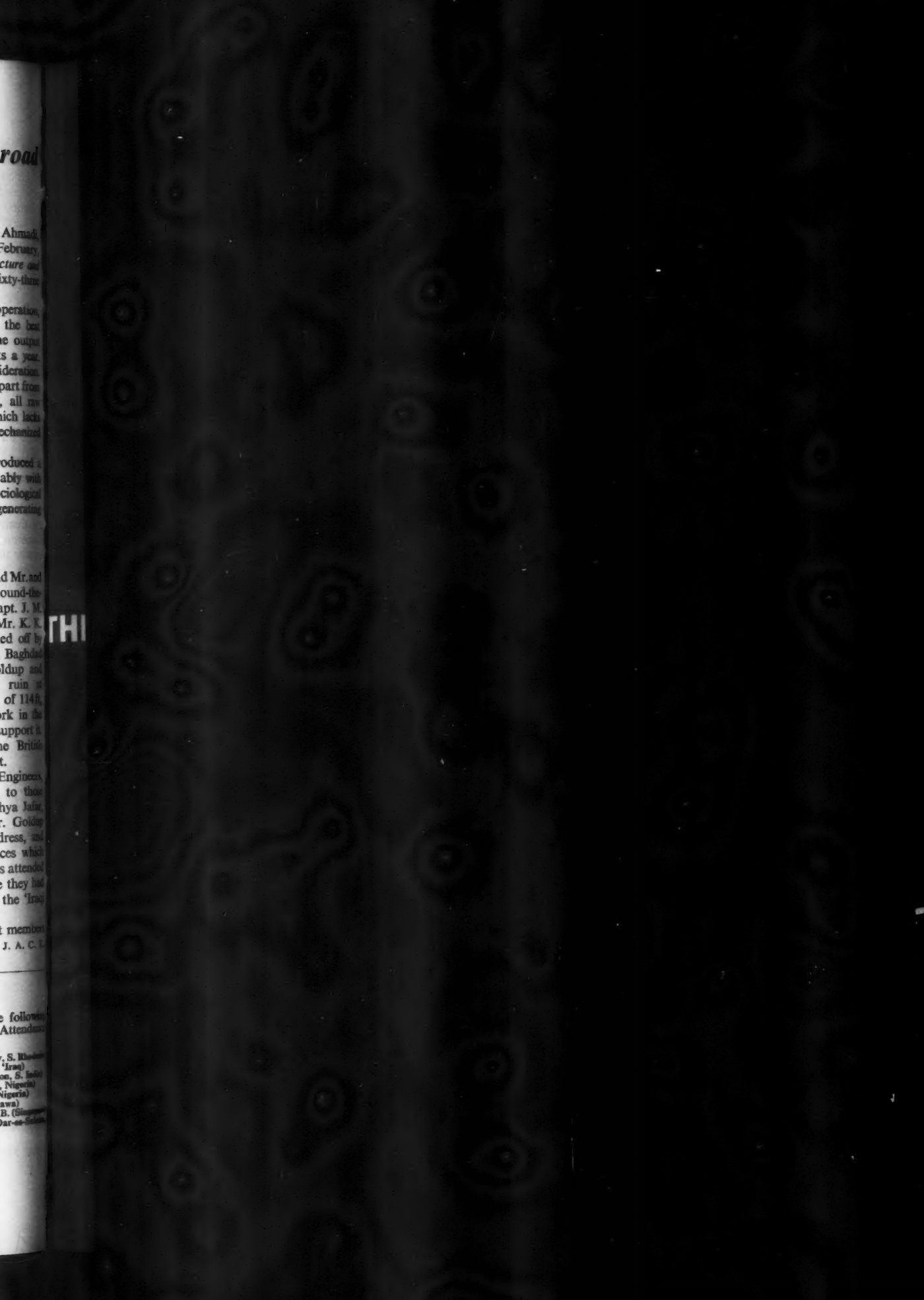
At sunrise on the 29th February, Mr. T. E. Goldup and Mr. and Mrs. W. K. Brasher arrived at Baghdad on their round-the-world journey. They were met at the airport by Capt. J. M. Morris, Mr. J. A. C. King, Mr. N. D. Fetto and Mr. K. K. Kouyoumdjian. Mr. and Mrs. Brasher were carried off by friends to discover the changes that had overtaken Baghdad since the days of their residence, while Mr. Goldup and Mr. King visited the 1500-year-old Sassanian ruin at Ctesiphon, which, with its span of 90 ft and height of 114 ft, is reputed to be the largest arch of pure brickwork in the world, erected without centring or scaffolding to support it.

The visitors were entertained to lunch by the British Ambassador, Sir Michael Wright, and Lady Wright.

After tea, as guests of the 'Iraqi Society of Engineers, Mr. Goldup and Mr. Brasher were introduced to those present by Capt. Morris and welcomed by Dr. Dhya Jafar, President of the 'Iraqi Society of Engineers. Mr. Goldup delivered a lecture based on his Presidential Address, and Mr. Brasher described the international conferences which they were to attend. Later in the evening, the visitors attended a reception and supper at the Mansur Club, where they had an opportunity of meeting several members of the 'Iraqi Government.

Before leaving 'Iraq for Bombay, the visitors met members of the Group in Basra. J. A. C. K.

OVERSEA ATTENDANCE REGISTER

During the period 17th April to 16th May 1958 the following members called at the Institution building and signed the Attendance Register of Oversea Members:

BIRD, J. F. (Salisbury, S. Rhodesia)
COATES, A. G. (Banias, Syria)
COLACO, J. A. (Bombay)
DAWSON, G. L. R. (Calcutta)
DRAKE, F. A. (Khartoum, Sudan)
GATES, B. G. (Melbourne)
GYI, M. (Mandalay, Burma)
KAPUR, K. K. (W. Germany)
KORAM, E. M. (Accra, Ghana)
MORLEY, W. (Salisbury, S. Rhodesia)
ODELL, H. A. (Kirkuk, 'Iraq)
SHARKEY, A. C. (Quilon, S. India)
SIDDALL, E. P. (Lagos, Nigeria)
SMITH, D. H. (Lagos, Nigeria)
WICKHAM, V. H. (Ottawa)
WOLSTENHOLME, O. B. (Singapore)
WOODWARD, J. W. (Dar-es-Salaam, Tanganyika)